Benefits from bonded mixes for complex Powder Metallurgy parts production

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Abstract

Precision parts tend to get more and more complex in geometry. For the production of P/M parts, cost efficiency is essential to remain viable and continue to be the process of choice versus other competing metal forming techniques. Production cost in combination with dimensional consistency play major roles in the design of the P/M process. Even with advanced equipment and controlled powder handling system the influence from filling characteristic for the material as such play an important role.

In this paper the influence of enhanced filling characteristic and segregation behavior by organically bonding of fine additives using the Starmix™ technique during a production period of more than 1 year for production parts are presented.

Introduction

Consistency of dimensional properties is an important factor to consider when designing processes for the P/M industry. There are many ways to improve the dimensional consistency. Two popular methods are changing the material handling system to produce mass flow and changing to a mix with bonded constituents. Keeping this in mind, the bonding method plays an important role in the consistency of the mix

One of the main causes of poor flowability in iron powder mixes is the nature and the amount of micronised additives that are used. In relatively large amounts graphite and lubricants in particular may have detrimental effects and leads to formation of powder bridges that can cause erratic flow. In powder handling system for production presses, these disturbances are often experienced in the hoppers and filling shoes, and even as poor filling performance in the die cavities. Furthermore, owing to the relatively low density of graphite and lubricant, they are especially prone to dusting. Graphite and lubricant dusting causes instability of the mix composition, which may increase the dimensional scatter of the sintered P/M parts

Bonding of the iron powder mixes is an efficient method to improve flow behavior. The use of organic binders for this purpose has been shown to give these desired effects as well as maintaining important parameters such as compressibility and mechanical properties at required levels [1,2,3, 4].

In this study, the focus is on comparing the performance of bonded mixes for mass produced P/M components at various time during one and a half year regarding weight scatter, productivity and scrap rate for the investigated components. Influence of control loop system on weight scatter is presented.

Experimental

Four different belt pulleys, figure 1 – 4, were compacted in hydraulic presses; Dorst TPA250/3HP and Dorst 160/3HP, with a bag-on-press system for optimised mass flow. The parts were all produced with three lower and two or three upper punches. The filling method utilized was gravity fill. The hydraulic presses were equipped with an advanced control system, allowing weight and compaction force measurement on every individual part. In order to limit the weight scatter, a control loop was used to adjust the filling height when five consecutive parts were outside 1.0% of the nominal weight of the component.

Chemical compositions of the mixes used for the investigated components are presented below. Both mix compositions were made as premix and Starmix^{TM} respectively.

Component : AHC100.29 + 1% Cu + 0.4% Graphite + 0,75% Amide wax
Component : ABC100.30 + 1% Cu + 0.4% Graphite + 0,75% Amide wax

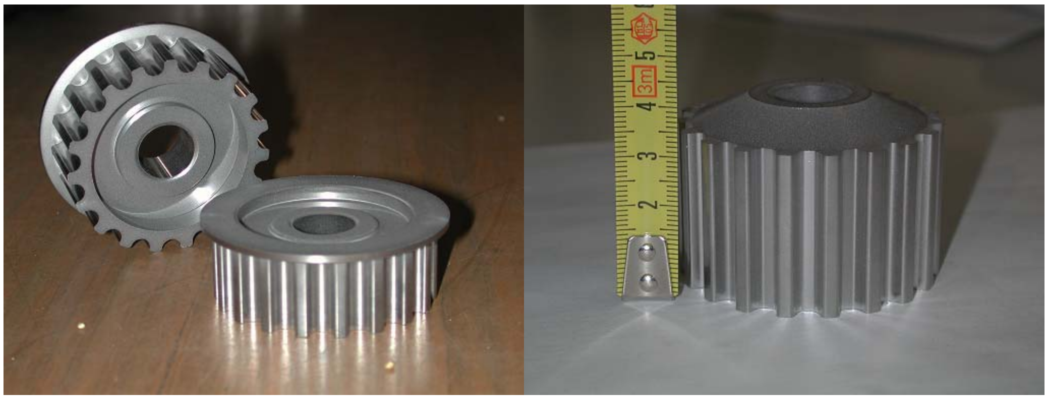

Figure 1. Two of the investigated components

Result
Component A
Outcome from weight measurements from different production runs are shown in figure 1 and 2

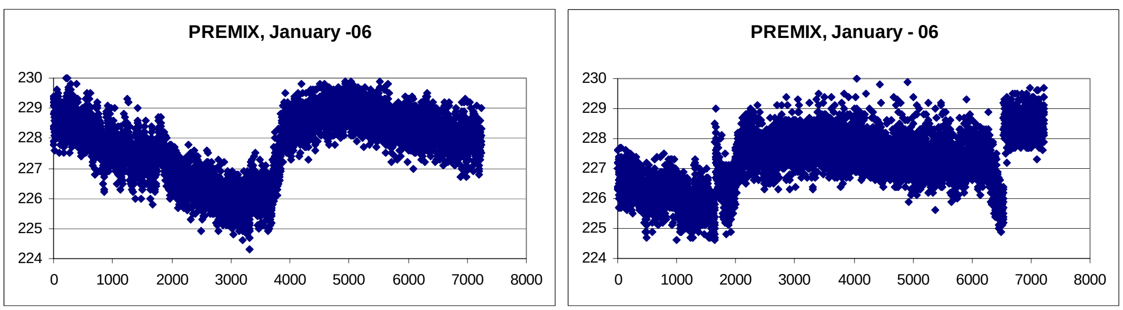

Figure 1 a,b Weight scatter premix

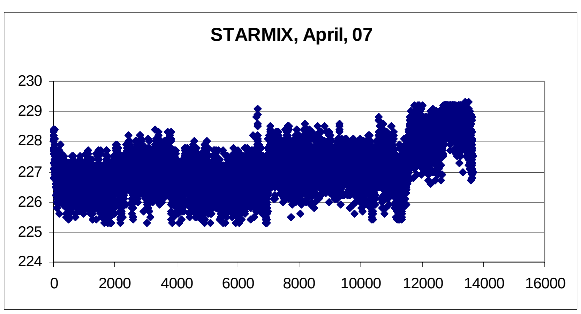

Figure 2 Weight scatter Starmix^{TM}.

In table 1 the standard deviation is shown for the investigated mixes.

Table 1. Weight scatter, standard deviation, productivity and components out of range for premix compared to Starmix™

	Mean weight (g)	Standard dev. (g)	Productivity Strokes/minute	Outside ±1% mean weight (%)
Premix, January - 06	227,735	1,08	10,6	2,06
Premix,January - 06	227,229	0,92	10,4	0,58
Starmix™ , April - 07	227,950	0,75	10,8	0,13

Same compaction rate is used for the componet. The weight scatter is reduced by at least 18% and the amount of component out of ±1% of the mean weight is reduced by at least a factor of 4,46.

Component B

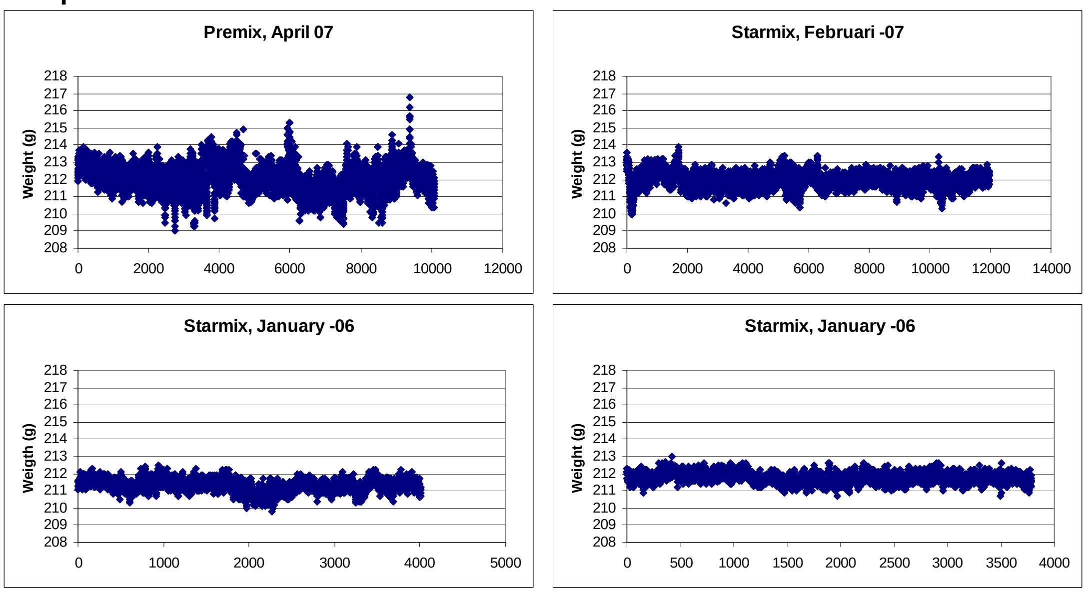

Figure 3 a-d. Weight scatter premix compared to Starmix™

From January -06 two production campaign are shown. Effect from start up sequences for a bonded mix can not be seen.

Table 2. Weight scatter, standard deviation, productivity and components out of range for premix compared to Starmix™

	Mean weight (g)	Standard dev. (g)	Productivity Strokes/minute	Outside ±1% mean weight (%)
Premix, April - 07	212,0	0,771	8,0	0,87
Starmix™. Febr - 07	212,0	0,38	11,9	0
Starmix™, Febr - 07	212,0	0,292	10,9	0
Starmix™, Febr - 07	211,9	0,406	8,6	0
Starmix™ Jan. -06	211,3	0,364	8,9	0
Starmix™, Jan. -06	211,7	0,295	9,0	0

During February -07 three production campaign were made, Productivity gain was investigated and an increase from 8,6 to 11,9 number of strokes/minute showed a weight scatter within the same range. Increased productivity by 49% without increased weight scatter or components out of weight range was obtained for this component.

The weight scatter is reduced to less than half Starmix™ compared to a premix. The number of components out of ±1% of the mean weight is 0,87% for a premix compared to 0% for a Starmix ™.

By individual measurements regarding weight and compaction force for each produced components the number of components outside ±1% of the nominal weight can be calculated. If five components are outside this range an adjustment of the filling height is done, called close loop control. The performance for a bonded mix with and without the use of close loop control is shown in figure 4.

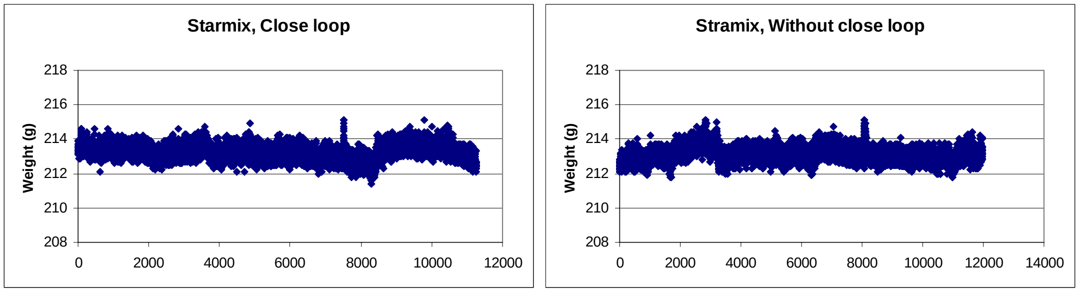

Figure 4. Effect of close loop control using Starmix™ mixes.

Table 4. Weight scatter, standard deviation, productivity and components out of range for premix compared to Starmix™

	Mean weight (g)	Standard dev. (g)	Productivity Strokes/minute	Outside ±1% mean weight
Starmix™ close loop	213,2	0,434	10,0	0
Starmix™ without close loop	213,1	0,420	10,0	0

Weight scatter and components out of weight range is the same using the close lop control system or not.

Component C

During 2007 new component were converted to be produced by using a bonded mix.

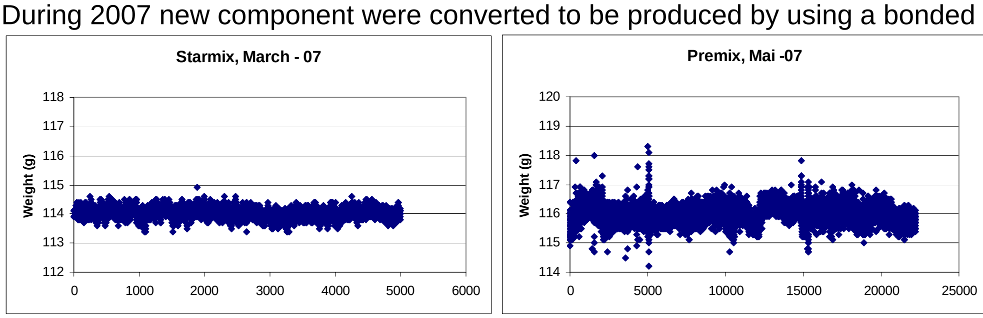

Figure 5 a, b. Weight scatter premix compared to Starmix™

Table 5. Weight scatter, standard deviation, productivity and components out of range for premix compared to Starmix™

	Mean weight (g)	Standard dev. (g)	Productivity Strokes/minute	Outside ±1% mean weight (%)
Premix Mai -07	116,0	0,255	9,5	0,08
Starmix™, March -07	114,0	0,179	7,9	0

The weight scatter is reduced by 30% or more for Starmix™ compared to a premix. The number of components out of ±1% of the mean weight is 0,08% for a premix compared to 0% for a Starmix ™. Still optimization is to be done regarding the productivity to at least match the premix at 9,7 strokes/minute.

Discussion

By bonding of light element like graphite and lubricant through the Starmix technology the flowability of such mix enhance the filling behavior of powder in the die cavity [5].
As a result the weight scatter and number of components out of ±1% of the mean weight is substantial reduced. The performance of such mix for a given geometry has been proven to maintain the scatter within ±1% of the mean weight that the close loop control system is not activated. This indicates that close loop control tool is still to be used as a tool to control the weight scatter when the geometry of parts is more difficult.

The geometry of the component, thin high walls, difficult powder transport geometries filling shoe design, number of "shakes" during filling will also affect the weight scatter difference between component types. Component A has a reduced weight scatter by at least 18% while component B has a reduced weight scatter of at least 47% this is a clear indication other factors do contribute to the outcome regarding weight scatter. Using bonded mixes is one part of the tools to improve final tolerances.
If the weight scatter can be controlled and maintained there is an option to gain productivity. For component B the weight scatter and number of components out of range clear indicate that this is possible. An increase from 8 to 11.9 strokes/minutes (49%) was obtained; still the weight scatter was reduced by 51% and no components out of range.

Taken all into account the performance for a bonded mix using the Starmix™ technique is superior to the one that is obtained by a premix. Weight scatter decreases for different investigated geometries from 18 to 47% and the number of parts out of range a significant reduced.

Cost saving by using a bonded mix based on the result obtained is obvious. Amount of cost savings is to be individual calculated by the user.

Conclusions

- Bonded mixes using Starmix™ reduces the weight scatter, standard deviation by 18 to 47%
- Number of parts out of range is significant reduced by use of Starmix™.
- Productivity gain of 49% for a given geometry was obtained.
- Significant cost saving by reduced number of components out of ±1% of nominal mean weight and increased productivity is indicated.

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