Reduced Weight Scatter with Bonded Powder Mixes

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Abstract

Organically bonded P/M mixes have been developed to improve the stability of dimensional properties by reducing the segregation of the mix constituents and improving the filling characteristics. Robustness and reliability are key factors for the promotion of P/M as cost effective substitute of competing manufacturing technologies. Based on the production of four different belt pulleys, this paper presents the achievement of reduced weight scatter and close dimensional control realizable by using a Starmix™ that is organically bonded.

Keywords : bonded mix, compaction, tolerances, weight scatter, productivity, lowest total cost

1. Introduction

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. The production cost in combination with dimensional consistency play major roles in the design of the P/M process. Considering the press operation, there are many ways to improve the dimensional accuracy and optimise productivity. Precision parts tend to get more and more complex in geometry, which makes hydraulic presses with multi level adaptor and advanced control systems, more or less a prerequisite for competitive production. The powder handling system, such as the bag-on-press concept [1] to provide mass flow, as well as the design of the fill shoe and tool to optimise the filling and powder transfer are other design parameters to consider. Even with advanced equipment, as described above, there is always a risk for segregation, due to density, size and morphological differences between elemental alloying particles and the base powder. Furthermore, fine additives like graphite and lubricants, may cause erratic flow behavior and poor air permeability, resulting in poor filling characteristics and uneven density distribution. Decreasing segregation and enhancement of the fillability were the main motive behind the development of bonded mixes. The performance of bonded mixes, diffusion bonded and organically bonded, has been described in several studies [2-3]. In the present study, the improvements achieved, when replacing plain mixes with tailored Starmix™ powder mixes in the compaction of four different belt pulleys are described.

2. Experimental and Results

Four different belt pulleys, which are denoted in this paper as components 1 – 4, were compacted in hydraulic presses, Dorst TPA250/3HP and Dorst TPA160/3HP, with a bag-on-press system for optimised mass flow. An illustrative drawing of the fourth component is presented as Fig. 1. The parts were all produced with three lower and two or three upper punches. The filling method utilised was gravity fill. The pulleys were all compacted to an approximate density of 6.7 g/cm³. 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. The nominal heights of the four components were between 21.5 mm and 26.5 mm and nominal weights were between 214 g and 288 g. Due to the fact that this study was performed as a substitution program in the normal production, the number of analysed parts of each mix type and component varied between 2500 and 24000.

Fig. 1. Drawing of belt pulley number 4

The chemical composition of the mixes, for each component type, used in this study is presented below. Both mix compositions were made as a plain mix and as Starmix™ respectively. All mixes include 0.75% Amide wax as lubricant.
Component 1 & 2: AHC100.29 + 1% Cu + 0.4% Graphite
Component 3 & 4: ABC100.30 + 1% Cu + 0.4% Graphite

The variation in green weight, expressed as one standard deviation, is presented in figure 2. The use of the bonded Starmix™ powder resulted in a substantial scatter reduction. The investigated parts have rather deep and narrow cavity sections with subsequent powder transfer. For these cases, Kondoh and Takemoto [4] as well as Cocks and Wu [5] have visually observed how entrapped air to a considerable extent influences the filling mechanism. The bonding of graphite and lubricant serves for a better air permeability in the powder mix. This in combination with very good filling characteristics, proven in earlier studies [2-3], of Starmix™ powders may explain the results obtained.

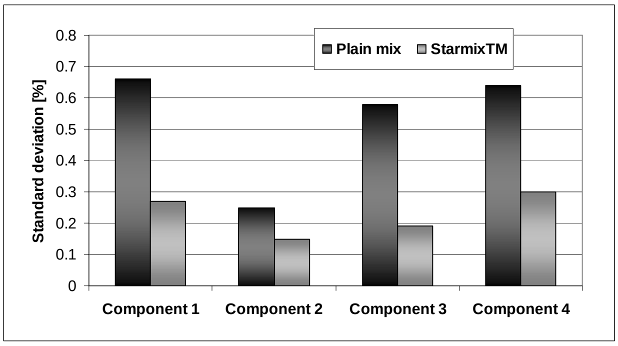

Fig. 2. Standard deviation of green weight.

Another way to assess the effect of improved weight scatter is to study the number of parts outside a certain range, in this study ±1.0% of the nominal weight. In Table 1 the percentage of parts outside this range is presented for each powder mix and component. The filling weight is correlated to the green density of the part and in some cases even to the final tolerances. The percentage of components outside a specified range could work as an estimate of the number of scrap compacts from the compaction operation.

Table 1. Percentage of compacts outside ±1.0% of the nominal weight for each component

Component	Plain mix [%]	Starmix™ [%]
1	5.60	0.00
2	0.29	0.00
3	12.80	0.06
4	3.96	0.04

Even, if this limit does not exactly correspond to the number of waste compacts from the press operation, the quality improvement obtained with the bonded mixes is obvious. This improvement implies that a substantial cost saving is possible, due to reduced waste material and processing time.
In the case of the fourth belt pulley, the weight scatter was reduced to half. For this component, a weight in a range of ±1.5% is acceptable. Parts outside this range are considered as waste, due to density and tolerance demands. Based on 24,000 compacted parts of the plain mix, two percent was outside the acceptable range and thus discarded. In the case of compacts of Starmix™, all the parts were in the specified range. The reduction in scrap rate is a direct cost saving and the general quality improvement is an important competitive parameter.
In addition to cost savings, due to better material utilisation, the superior filling characteristics of the Starmix™ powder compared to a plain mix, allow an increased productivity. In the present case, the parts from the Starmix™ powder were compacted at twelve strokes per minute compared to ten for the plain mix. The higher compaction rate was enabled mainly due to shorter filling sequence. The increase in productivity directly affects other production costs such as labor and depreciation related to the press

3. Summary

By utilising the organically bonded mix, Starmix™, a substantial productivity and weight scatter improvement was obtained in a substitution program of four different belt pulleys. The productivity increase was mainly due to a shorter filling sequence, enabled by the superior filling characteristics of the bonded mix. The bonding of light additives and optimisation of the Starmix™, to avoid erratic flow patterns and bridging effects provided a weight scatter reduction of more than 50% and a decrease in the number of rejected components from two percent to zero. The combined benefit of increased productivity and better material utilisation presented in this paper, shows that a considerable cost saving in the press operation is possible.

4. References

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