Mix Concept Engineered for High Precision VVT components

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***Abstract* -** Variable valve timing (VVT) systems allow for the perfect combination of performance increase, better economy and improved emission control. The components used in a VVT system are typically highly complex in design and challenging to manufacture. Therefore, successful large volume production of high-tolerance VVT components requires a metal powder that continuously delivers high quality and consistent results. The powder solution has to be properly designed to optimize powder handling and processing conditions to fulfill product quality and performance requirements at the total lowest cost for the producers in their manufacturing.
With all these aspects in mind a metal powder mix concept specifically engineered for manufacturing of high precision VVT components has been developed and will be presented in this paper.

Key words: High precision, Productivity, Machinability

INTRODUCTION

Successful large volume production of high-tolerance VVT components requires a metal powder that continuously delivers high quality and consistent results. The powder solution has to be properly designed to optimize powder handling, compacting, sintering and machining and other post sintering operations to fulfill product quality and performance requirements with reduced impact on the environment at the total lowest cost for the producers in their manufacturing.
With all these aspects in mind combined with knowledge about function and requirements on components used in modern VVT systems, a mix concept specifically engineered for manufacturing of high precision VVT components has been developed. The ambition is to provide a metal powder mix concept that improve dimensional precision and stability combined with process robustness and high productivity.
This mix concept makes it possible to drastically improve tolerances with less scrap, enhance productivity and minimize machining costs as direct results.

EXPERIMENTAL

A. Materials

Fe-Cu-C is the most common alloy system used in the PM industry. In this presentation two mixes, Mix A and Mix B, have been prepared and evaluated. Both mixes are based on Höganäs AB high compressible iron powder, AHC 100.29. Both mixes contain 2%Cu, 0.80% C and 0.6% lubricant. In Mix A the Cu has been added as a 200 mesh powder and in Mix B the Cu has been added in diffusion bonded form. Amide wax was used as lubricant in Mix A and Mix B contained a lubricant engineered for enhanced productivity.

B. Testing

A ring component with 25/35 mm (ID/OD) and 20 mm height was used for the evaluation. The set value for the density of the pressed component was 6.9 g/cm3 and the weight was around 65 g. Parts for evaluation were compacted of each mixes with a Dorst electrical 70T press. Two compaction modules, A and B, were used to evaluate influence of different filling shoe speed and dwelling time for each mix, Table 1. The weight of all parts was on-line registered by the logging system of the press.

Table 1. Compaction modules A and B

Modules	Fill shoe speed mm/s	Dwell time sec	Compaction speed strokes/min
A	100	1.2	5.6
B	150	0.8	6.7

RESULTS

Weight Scatter

As can be seen from Figure 1, the weight scatter obtained when testing at module A are very similar for Mix A and Mix B. However, at the higher filling shoe speed used in module B, mix B shows more than 50% lower scatter than Mix A. By the improved powder flow and filling capability of Mix B, filling speed can be increased by up to 20%. This also means that productivity could be enhanced by up to 20% with maintained dimensional precision.

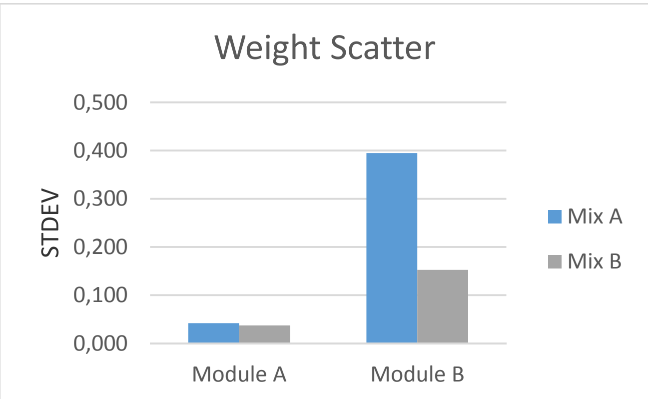

Fig. 1. Weight scatter for Mix A and Mix B

PRODUCTION TEST

A production test was carried out at a VVT parts manufacturer. The component tested, a VVT stator, is shown together with its data in Figure 2 below.

Weight: 202g
Green density: 6.95 g/cm3
Outerdiameter:79.95±0.03 mm
Height: 16.5 ±0.05 mm

Fig. 2. VVT stator used in production test

Compaction was carried out with a 500 Ton Yoshizuka Mechanical press. Compaction rate was 6.5 parts/min with a filling time of 4~5 s by gravity filling.

Dimensional change was determined by measuring outer diameter before and after sintering.

RESULTS

Weight Scatter

As can be seen from Figure 3, the weight scatter obtained with Mix B is more than 50% lower than for Mix A. This is due to the better powder flow and filling characteristics of Mix B which ensures more homogenous filling of the die cavity, minimizing the need for readjusting press settings when changing a powder batch.

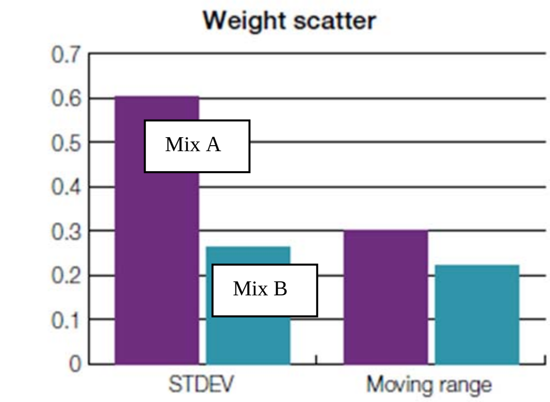

Fig. 3. Weight scatter of VVT stator obtained with Mix A and Mix B

Dimensional change stability

As can be seen from Figure 4 below the dimensional scatter of the outer diameter after compaction is almost the same and on a very low level for both mixes. However, after sintering, mix

B shows a significantly smaller scatter of the outer diameter compared to mix A. The dimensional scatter could be reduced by more than 50%.
This excellent dimensional stability is primarily due to the unique alloying concepts used in mix B. These enable both improved die filling capability and consistent robust conditions during sintering.
By achieving a product with increased dimensional precision, processing steps such as sizing, turning and grinding, can be reduced or eliminated saving operation costs.

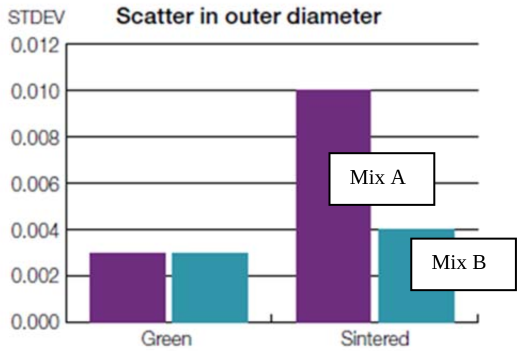

Fig. 4.Dimensional scatter of outer diameter of VVT stator after compaction and sintering for mix A and B.

CONCLUSIONS

The mix concept described in this paper makes it possible to drastically improve tolerances and enhance productivity with decreased costs as direct result.