MetaCause Process Optimizer

Case Study 5 - Chemical Analysis

This example shows the effective use of the MetaCause Process Optimizer in deciding the optimal chemical composition, while maintaining all components of the melt within the specifications allowed by the customer.

The Problem:

The Department of Trade and Industry (DTI) funded a studio project in UK to investigate the effect of alloy composition on a Nickel based super alloy. The alloy is known to have variable castability, as shrinkage defects are common.

There was no immediate explanation for the occurrence of the defects, and physics based simulation techniques were also unable to justify their erratic occurrence. The solution could be held within the chemical composition of the alloy, and this case study explores the effect composition of the melt has on the shrinkage found in parts.

32 chemical components of the melt were identified for analysis, and are shown below:

Carbon	C	Boron	B	Molybdenum	Mo	Tantalum	Ta
Silicon	Si	Bismuth	Bi	Nitrogen	N	Tellurium	Te
Manganese	Mn	Cobalt	Co	Niobium	Nb	Titanium	Ti
Phosphorus	P	Chromium	Cr	Oxygen	O	Thallium	Tl
Sulphur	S	Copper	Cu	Lead	Pb	Tungsten	W
Silver	Ag	Iron	Fe	Antimony	Sb	Zinc	Zn
Aluminium	Al	Gallium	Ga	Selenium	Se	Zirconium	Zr
Arsenic	As	Magnesium	Mg	Tin	Sn		
Aluminium + Titanium							

Although the level of each component was maintained within the specification of the alloy, there is room for alterations to be made. The objective of this study is clear,

Aim : "To find out if the occurrence of shrinkage defects can be controlled by altering any of the chemical components to the high or low end of the range specified for this alloy"

The Solution:

By analysing the data with MetaCause Process Optimizer analysis, correlations between levels of the components and the occurrence of shrinkage can be discovered using a logical pattern recognition approach. The results for this case will show if there is any evidence to suggest if levels of any of the components in the melt are linked to the occurrence (or non-occurrence) of shrinkage.
The analysis techniques are not based on statistical methods and no pre-determined assumptions or fitting is applied to the data. Its evidence based optimisation engine has advanced self-learning abilities that can un-tangle the effect of many interactions occurring at once, giving it the ability to accurately characterise patterns in process data.

The Results:

The results for this case will show if there is any evidence to suggest that "High" or "Low" levels of any of the components in the melt are linked to the occurrence (or non-occurrence) of shrinkage.
The table below shows the most significant findings.

Response: Shrinkage

Optimal Process Settings		
Factor	**Setting**	**Importance Weighting**
Copper	High	79.0%
Tantalum	High	52.5%
Oxygen	Low	52.3%
Boron	High	51.5%
Nitrogen	Low	50.5%
Iron	High	48.3%
Cobalt	High	47.2%
Molybdenum	High	47.1%
Carbon	High	45.9%
Niobium	Low	41.5%

Process Settings to Avoid		
Factor	**Setting**	**Importance Weighting**
Molybdenum	Low	54.9%
Cobalt	Low	47.3%
Carbon	Low	46.4%
Zirconium	Low	45.1%
Tantalum	Low	43.7%
Tungsten	High	43.1%
Oxygen	High	42.8%
Iron	Low	42.3%
Nitrogen	High	42.3%
Boron	Low	41.4%
Niobium	High	40.7%

In the results for this case, the most important component ranges that have been found to reduce shrinkage are listed under the "Optimal Settings" heading, and the levels of components which are likely to cause shrinkage are summarised in the "Settings to Avoid" section.

The Confirmation:

A confirmation trial was also performed on these results. The process settings to avoid were implemented in the process and the number of castings rejected increased.

It was found that using the above information to look at parts produced after the trial, it was possible to predict “good” and “bad” batches by just looking at the chemical composition of the batch and comparing it with the findings of the reports above.

The Conclusions:

This case study has demonstrated the true strength of the MetaCause Process optimizer on a complex chemical problem. By looking at process data, the true relationships can be easily extracted and directly used in the process. The findings of this study have given the foundry experts guidance about the most likely causes and solutions for the shrinkage defects, in a format that can be easily implemented in the process.

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