

CASE STUDY

Comprehensive Evaluation Plan Designed to Confirm Performance of Enhanced Product

Innovations in ceramic materials used in metallurgical processes are often driven by customer needs, and are typically rooted in sound scientific and engineering principles. Nonetheless, decisions are ultimately made based on proven performance and cost-effective solutions.

A manufacturer of specialty fused silica and alumina shapes used in vacuum metallurgy processes had an interest in developing an enhanced product composition for their customers' more demanding applications. Current compositions were susceptible to a common problem inherent to the process, namely reduction-oxidation reactions occurring along the substrate-alloy boundary. The manufacturer's scientists and engineers felt confident that they had developed a superior composition, but were now faced with the task of justifying the increased product cost. The manufacturer desired a testing plan that was capable of correlating theoretical performance and laboratory analyses with "real-world" functionality. However, in-house testing capabilities were limited, and user feedback on previous trial products had been incomplete and unreliable.

Opus Technologies was hired to develop a comprehensive, statistically valid evaluation plan to support the objectives of this project. The plan was required to define, in detail, a selection of testing methods, procedures, and measurement criteria that would provide a high level of confidence to the manufacturer, and their customers, that the enhanced composition was truly effective.

Based on the range of chemical compositions of the alloys processed by the end user, the client's current product line, and competitors' products, it was agreed that the following were to be evaluated:

- Ten (10) ceramic substrate materials, including the enhanced product composition
- Six (6) alloy compositions, with varying chemistries and degrees of reactivity

Table 1 illustrates the testing and analysis methods selected for this evaluation. For each item, the client was also provided with a comprehensive discussion regarding the following:

- Cost (including benefit analysis)
- List of pros and cons
- List of recommended sources
- Sample requirements

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Table 1 – Testing and Analysis Matrix

	Supervised Trials at Customer's Facility	Mock Trials at Neutral Test Facility	Small Scale Laboratory Replication of Interface
Finished Part Inspection	X		
Contact Angle Measurement			X
Metallographic Examination of Interface	X	X	X
Chemical Analysis	X	X	X
Oxide Raft Analysis		X	X
Visual Inspection and Photographic Documentation	X	X	X

Given the quantity of substrates and alloys involved, and the use of multiple measurement systems, it was obvious that any type of full-factorial experiment would be impractical. Therefore, it was necessary to design a multi-phase experiment that, while cost-effective, would still provide statistically valid results.

Using a combination of commonly accepted “Design of Experiment” techniques, an acceptable, cost-effective evaluation plan was developed that focused on the following:

- Measurement system capability
- Favorable “quality loss function” values
- Fractional-factorial testing
- Iterative sequencing
- Maximization of S/N ratios

In conclusion, due to the nature of the factors involved and the type of analysis required, only a thorough understanding of the situation and a properly designed evaluation would be able to effectively satisfy the manufacturer’s (and ultimately their customers’) needs.

Only a fraction of the data collected and analyzed during the duration of this project are provided in this case study, and are presented to give the reader a brief synopsis of the project’s objectives, results and conclusions. Additional information will be supplied upon request, provided doing so does not violate existing non-disclosure agreements or result in a conflict of interest situation.