intellegens

CASE STUDY

Machine learning used to achieve drastic improvement in performance of hardfacing welding consumables for Welding Alloys Group

Executive Summary

Wear is one of the most challenging problems faced by heavy industry. For example, in the mining industry alone, approximately 17% of the consumed energy is used to combat wear failure, accounting for 2.7% of global CO_2 emissions[1]. If these figures are multiplied for every sector (construction, oil, and gas, etc.) the scale of the problem becomes evident. Thus avoiding or minimising wear is a top priority in industry.

One of the most common methods to combat wear is by welding highly alloyed consumables (hardfacing materials) onto the surfaces of components. These consumables must meet stringent requirements on safety, cost, environmental impact, and performance. Wear performance is determined by a complex interaction of properties, therefore optimising cost/benefit for hardfacing materials is a highly complex operation.

This case study describes the journey taken by Welding Alloys Group (WAG) and Intellegens in applying machine learning to this problem, which **resulted in the development of an improved hardfacing material with drastic cost/benefit advantages, not only from a performance but also from an environmental point of view**.

Challenge

Wear is a very complex phenomenon. The common conception that high hardness secures high wear-resistant properties is misleading. Optimum wear resistance is defined by a complex interaction of chemical and mechanical properties of every material involved in the application. These properties include composition, hardness, toughness, Young's modulus, grain size, phase composition, etc. External parameters such as temperature, pressure, and humidity also play important roles.

In addition, random and/or systematic variations on wires and hardfacing welding procedures result in finished products with large discrepancies in performance. Environmental costs due to excessive use of highly polluting Chromium (Cr) are also a big concern, as well as the increasingly strict environmental regulations that push for lean welding consumables.

The goal of this project was to take one high-Cr cast iron-based welding consumable and to optimise cost/benefit as a function of chemical composition, based on abrasion-resistant standard methods as a performance metric, using the Alchemite™ machine learning toolkit.

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Solution

Alchemite™ Engine is Intellegens' unique deep learning tool, which uses the power of deep neural networks to build comprehensive models across multiple compositions and material properties from sparse experimental data. The model for hardfacing materials was constructed with composition and physical property data from the literature as well as historical data from WAG. Weight loss was used as a measure of resistance to wear.

Methodology

Stage 1: Model building and preliminary material design
Alchemite™ defined the most influential parameters in performance and suggested the first round of theoretical compositions. WAG engineers confirmed and approved manufacturing.

Stage 2: Validation
Formulations were manufactured, tested and validated against predicted values, showing acceptable agreement and falling within the calculated uncertainty.

Stage 3: Refinement
Additional iterations were carried out allowing the model to be refined.

Stage 4: Conclusion of modelling and laboratory work
A new formulation was defined. Laboratory tests showed comparable performance to existing products, but with a reduction of alloying elements by up to 50%, and price reduction of between 10% and 15%.

Alchemite™ proposed an improved hardfacing consumable with drastic cost/benefit advantages from a performance and environmental point of view

Key outcomes

- **Alchemite's predictions were experimentally validated**. The compositions selected for validation differed considerably from existing materials. Data on these new materials significantly improved the model.
- Alchemite™ was able to propose an **improved, more cost-efficient, and more environmentally friendly alternative** to the currently used hardfacing material.
- WAG has taken this material forward and is now carrying out **industrial-scale performance trials**.

References

[1] Global energy consumption due to friction and wear in the mining industry. Tribology International. Volume 115, November 2017, Pages 116-139

> Jean-Marie Bonnel (Technical Director) and Mario Cordero (Innovation, R&D Manager), leaders of the project at WAG, agree that:
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> **"The combination of extensive technical know-how and experimental data provided by WAG, and the unique deep learning algorithms provided by Intellegens, resulted in an improved material with drastic cost/benefit advantages."**

Future opportunities

This outcome represents a significant step forward for Welding Alloys Group. It has shown a successful approach to using state of the art computational methods for the improvement of existing, and design of new, welding consumables. This approach is continuing for other ranges of welding consumables.

About Welding Alloys Group

Welding Alloys Group is the go-to provider for advanced welding consumables, automated equipment for wear protection, and engineered wear solutions. Welding Alloys Group is committed to forming close customer relationships and has established numerous industry partnerships as a total solution supplier - from consumables and machines to integrated engineering solutions.
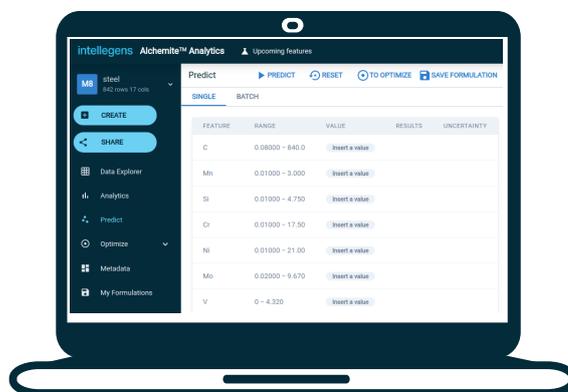
About Intellegens

Intellegens has developed a unique artificial intelligence engine, Alchemite™, for training neural networks from sparse and noisy data, typical of real-world data. Alchemite™ is the deep learning platform for material and process optimisation to:

- **Optimise formulations for performance, cost, or environmental impact**
- **Guide experiments, reducing by up to 80% the number of tests needed**
- **Validate and identify outliers and interesting data**

Alchemite™ can be licensed as a SaaS product for scientists, engineers, and technicians, or stand-alone use by customer data analytics teams.

For more information, visit our website.

> Want to learn more about how our AI technology can be applied to your specific needs? Contact us to learn more at info@intellegens.ai