Meeting Mill Demand

Pieter du Plessis, Welding Alloys, discusses the optimisation of mills for the cement production process.

Introduction

Since the invention of milling and crushing equipment, loss of material due to wear of mill components has been a large contributing factor in the operating cost versus the number of tons of cement produced. The impact of wear on the cement industry is enormous and is experienced across a wide variety of plant and equipment, but particularly in the mills used by the industry. As a vital component in the cement manufacturing process, mills need to run at optimum performance for as long as possible to increase productivity, while simultaneously reducing operating cost per ton.

A mill that performs at optimum designed levels for longer periods of time produces more product at consistent quality, uses less energy, does less re-grinding, requires less maintenance, and ultimately costs less to operate. In the current economical atmosphere, mills need to run for as long as possible at the highest possible throughput.

Refurbishment and repairs of grinding components by means of hardfacing has been around for quite some time. Various consumable manufacturers produce welding consumables in an array of specifications, all aimed at being able to increase the wear life of these components. The demands from the cement and other industries has ensured the development of some ingenious concepts and materials, some with great success and others not so great, all coming at their own cost and with claims of increasing wear life and decreasing cost of ownership.

Smart Welding Concept

Welding Alloys Group believes in providing the customer with an optimised solution, instead of just a product. This approach, and years of hands-on involvement in the cement industry have led to the development of their Smart Welding Concept. This concept is based on the following principles:

- A thorough investigation of the unique operating conditions of the equipment to be refurbished based on a wear audit.
- An optimised refurbishment programme aimed at refurbishing components in-time to prevent excessive wear, keeping costs at bay, while minimising downtime needed for refurbishment.
- Improved, tried, and tested welding processes and procedures to ensure the best possible wear resistant properties of the weld deposits.
- A selection of application and condition-specific hardfacing consumables to optimise wear life while decreasing cost of ownership.

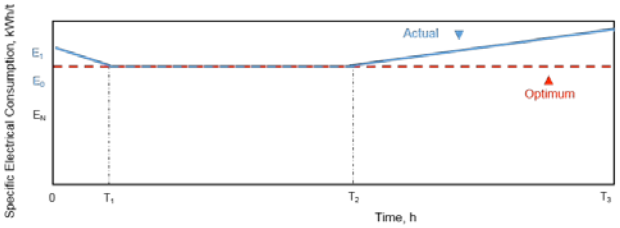

Figure 1. Showing the effects of component wear on the electricity consumption of a mill to produce the same amount of product over the life cycle of the grinding components.

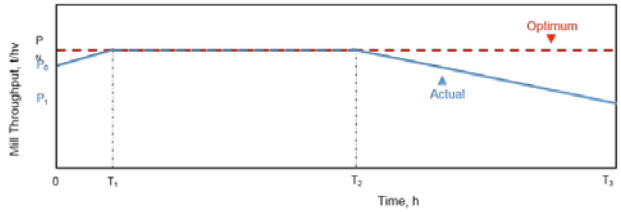

Figure 2. This chart reflects the mill throughput over the same period of time.

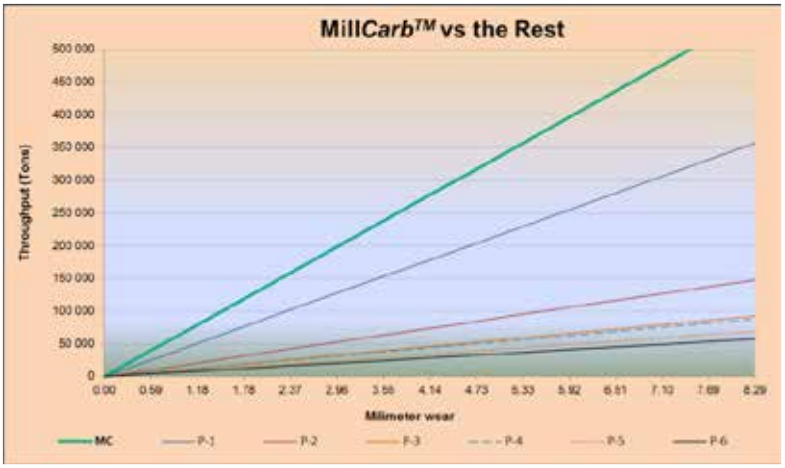

Figure 3. The wear rate of MillCarb™ in a real-time coal grinding environment compared to other industry leading products, clearly distinguishing it from the competition. After 300 000 t of throughput, MillCarb™ showed the same levels of wear than what industry leading ceramic embedded rollers experience after only 190 000 t.

Figures 1 and 2 are typical of mill performance. Figure 1 is a reflection of a standard mill performance chart based on total operating hours versus electricity consumption per ton (kWh/t) across the life cycle of the grinding components (tyres and table) in the mill. The initial period up to T1 requires a higher kWh/t demand due to the run-in period of the mill while performance is not optimised. Between T1 and T2, the mill is running at optimal conditions and as soon as component wear reaches the T2 threshold, electricity consumption versus throughput again increases due to excessive component wear causing reduced efficiencies. The aim of The Smart Welding Concept is to reduce the period up to the T1 threshold and to have the mill running for as long as possible between the T1 and T2 thresholds. Another aim is to refurbish the components as soon as possible after the T2 threshold has been reached.

Through continuously striving to develop new solutions to enable our customers to produce more tons at a lower cost, The Welding Alloys Group has developed *MillCarb*™.

What is *MillCarb*?

MillCarb has been developed together with industry leading mill OEM's and experts in material science to ensure optimum performance when needed most. *MillCarb* offers new grinding components, setting new standards for the cement and coal milling industries.

In short, *MillCarb* is a fully repairable, welded ceramic composite metal matrix alloy providing an optimised engineered wear protection solution for grinding components.

During real-time field testing under normal operating conditions, *MillCarb* has outperformed all other materials it has been tested against. Figure 3 shows the performance of *MillCarb* compared to various other solutions in a coal milling environment. Testing was conducted in collaboration with leading mill OEM's and end users. This approach ensured that the results from the *MillCarb* tests are as realistic as possible. Testing in the cement industry is currently underway, with very promising preliminary feedback.

Like all other hardfacing solutions, *MillCarb* is a welded solution which uses a Flux Cored Arc Welding consumable, but with the addition of graded ceramic-carbide particles to produce an overlay with exceptional wear resistant properties.

The combination of the welded chromium and complex carbide rich matrix and the added ceramic-carbide particles provide a solution with class leading wear resistance. The range of welding consumables available for the *MillCarb* matrix have been in service in the power, cement, and associated industries for many years and have proven themselves to be very effective in providing optimum wear resistance through the formation of chromium and complex carbides during the solidification phases of these alloys. By adding a second component (ceramic-carbide particles) to the welding process, the wear resistance of the matrix is dramatically improved. These particles act as deflectors effectively repelling abrasive particles away from the welded surface of the grinding component. With hardness far in excess of 1000 HV_{10}, the ceramic-carbide particles are harder and more abrasion resistant than anything else present inside a cement mill. Figures 4 and 5 provide a graphic explanation of the mechanisms at work when abrasive particles impact on standard hardfaced and *MillCarb* surfaces.

The MillCarb micrograph (Figure 6) clearly shows the ceramic-carbide particles embedded into the welded matrix. MillCarb is a result of intensive research, Finite Element Analysis (FEA), industry testing, and innovation put to work.

The success of any hardfacing solution lies in its ability to effectively resist wear from the first hour of operation right through the thickness of the overlay at a lower cost of ownership than the solution it is replacing. Hardfacing solutions are typically sold in terms of cost/ kg of deposited material. This cost is constant for the entire thickness of the overlay. From a customer point of view, the expectation should be that the wear resistance of the overlay should also be constant. Unfortunately, in some instances due to uncontrolled welding parameters, excessive base material dilution and an incorrect or low-cost alloy selection, the wear rate would initially be acceptable, but would increase as the first layers wear off.

The tight controls and unique welding process of *MillCarb* result in a final product of up to 20 mm thick, embedded with uniformly distributed ceramic-carbide particles throughout the entire thickness of the welded overlay. The size, shape, make-up, and deposition techniques of these particles were determined through a scientific approach, combined with real-time testing ensuring that particle segregation is virtually eliminated.

One of the advantages of MillCarb is the uniform wear rate throughout the deposit thickness. Dilution from the base material has little effect on the wear rate and the solution does not necessarily rely on the choice of welding consumable, chemistry, and cooling rates for its success.

The ultra-high hardness of the ceramic-carbide particles combined with a choice of performance proven Welding Alloys Flux Cored Arc Welding consumables produce a weld deposit consisting of primary and secondary chromium and complex carbides embedded with ceramic-carbide particles ensuring class leading wear resistance in all areas of the welded overlay.

The size and geometry of the ceramic-carbide particles, as well as the exact area of delivery during welding, results in its full integration within the welded matrix, preventing them from being destroyed by the heat of the arc. This is essential in retaining the geometry and particle size, establishing the superior wear resistance of the MillCarb overlay.

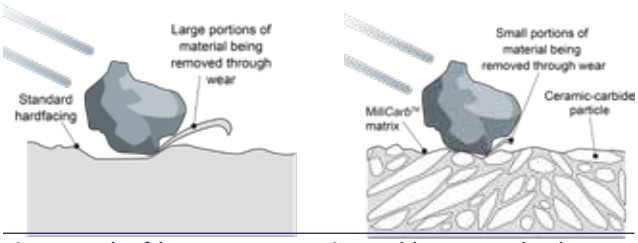

Figure 4. (Left) Wear as experienced by a standard harfaced material through continuous impact of abrasive particles on its surface. (Right) Wear as experienced by MillCarb™ in the same environment as standard hardfacing. Note the much smaller portion of material being removed from its surface. This is due to the ultra-hard Ceramic-Carbide particles effectively reducing wear.

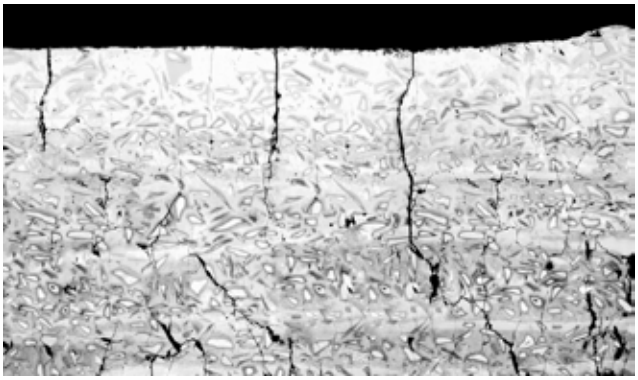

Fig. 6. The microstructure of 5-layers of MillCarb™, showing uniform distribution of the Ceramic-Carbide particles throughout the thickness of the entire weld deposit. The stress relieve cracks are normal due to the high hardness and low ductility of the overlay.

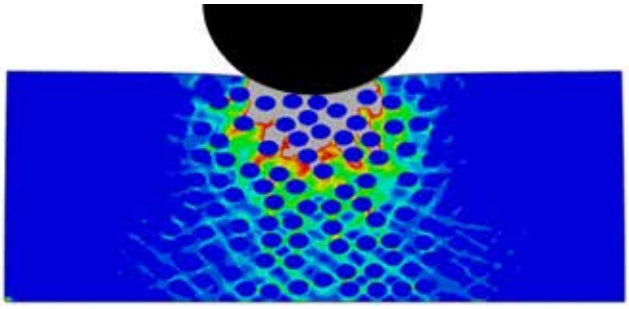

Figure 7. The finite element analysis above shows the importance of well distributed hard phases in the stress distribution within the MillCarb™ weld deposit, when exposed to heavy load pressure.

An optimised solution

Through the methodology and principles of The Smart Welding Concept, data gathered through this concept is analysed by mill, wear, and welding experts. The proposed solution ensures that MillCarb is delivered where it is needed most and where it will have the biggest impact in reducing operational cost.

Depending on the component being refurbished, the operational conditions and the material being milled, this could mean that MillCarb is required across the entire surface of the component, or in some instances only in the high wear areas. With this approach, optimum performance is achieved while keeping operational cost per ton as low as possible.

About the author

Pieter works as a Product Engineer for Welding Alloys Group, where he has worked for almost eight years. He has an N.Dip. in Physical Metallurgy and an M. Eng. in Materials and Metallurgy with extensive experience in the welding industry, the aerospace industry, and the foundry industry.