REDUCE FATIGUE, IMPROVE EFFICIENCY

Justin McAdams and Charles Constançon, BMT, USA, explain how the company's new dragline modification and repair scheme has reduced downtime and outage costs caused by fatigued dragline parts.

Draglines are large mining machinery typically used to remove overburden. BMT has been involved with dragline maintenance issues and improvement strategies for over 40 years. Key areas of failure include the boom, mast and roller circle. A more sophisticated approach to maintenance can, in some cases, reduce maintenance and inspection workloads, and extend the fatigue life of these structures. BMT has completed numerous finite element analyses (FEA) identifying areas that are prone to high stress and fatigue of dragline structures. A map can then be created to guide maintenance inspectors on where to focus their attention, ultimately reducing the time needed for inspections.

While maintenance planning in mining has been systematised for many years, techniques such as reliability-centred maintenance (RCM), which have been used over the last 40 years in other industries, including aerospace, are being increasingly applied to mining machinery maintenance. RCM techniques can help identify the component failures that impact availability most significantly, thereby enabling appropriate solutions to be devised.

Modification and repair scheme

Working closely with Westmoreland Coal Company, BMT recently deployed its innovative DuraCluster modification and repair scheme, which dramatically improves the fatigue performance of cluster joints on existing tubular dragline boom designs (Figure 1). This involves replacing a number of fatigued boom clusters with DuraClusters to demonstrate both the ease of installation and operational suitability.

Figure 1. Dragline booms are sensitive to dynamic loading events and operator influence, and are prone to fatigue failure at the cluster joints. Fatigue failure of a cluster joint can reduce or eliminate the effective lateral support of the main chord and result in a catastrophic buckling collapse of the boom. The DuraCluster modifications in the photo can be identified by the freshly painted white areas.

Once implemented, this modification for tubular boom draglines significantly reduces maintenance and inspection workloads and dramatically reduces the problem of long-term fatigue cracking associated with the existing cluster design. BMT was able to offer both reduced downtime and outage costs. Once installed, DuraCluster also reduces the risks to operators and maintenance teams in having to lower the boom and carry out complicated weld repairs with limited access. The installation for Westmoreland was successfully completed in the allocated timeframe and the dragline was returned to duty.

The long booms of draglines comprise a number of tubular chords with interconnecting lacings welded to the chords at cluster joints. Stresses are concentrated at the cluster joint weldments and over time, fatigue cracking becomes endemic. This methodology prevents the need to cut and replace windows in lacings by removing the problematic design detail and improving load paths. Furthermore, DuraCluster can dramatically extend the fatigue life of dragline booms by reducing the stress concentrations (Figure 3).

Reduced machine outage time

A boom replacement can cost in the region of US$20 million and can require machine outage for up to three months. With BMT's modification and repair scheme, the cluster design can be upgraded in approximately one week per cluster, depending on the extent of chord repair required, while multiple clusters can be modified simultaneously. With equivalent repair costs reduced to approximately US$2 million, this is an extremely attractive incentive for mining companies. While DuraCluster provides a step change in life to cracking for tubular boom construction, it is equally applicable to tubular masts.

The innovative design allows lacings to be cut away from the chord, providing easy access to remove damaged or previously repaired material. The exposed chord can then be inspected and fully weld repaired before installing the plate. Full patent rights for the DuraCluster design have been granted in Australia, South Africa, India and North America, and discussions are taking place with potential clients in all these territories.

Roller circle

Another area of significant technological advances made over the past 15 - 20 years is the dragline slew bearing, also known as the roller circle. The roller circle and its supporting structures immediately above and below are vital mechanical and structural components of the dragline.

Installation and maintenance activities in these areas carried out to a poor standard can lead to large amounts of cracking in the tub and the revolving frame and very poor bearing life. BMT has developed supporting and repair techniques ensuring that the welding and machining of the upper and lower rail pads are done to a high standard resulting in good bearing load distribution and long roller circle service life.

Although there is welcome optimism for the future of the mining industry as a whole, mining companies are focusing heavily on cost efficiencies and productivity gains in the short to medium-term. Pushing innovation and embracing the technologies that are available can play an integral role in realising these efficiencies, but this is only one part of the jigsaw. Effective maintenance strategies that consider tools and techniques, such as RCM, and which are simultaneously aligned with the need to be production-focused will create a step change in maintenance management, helping to improve productivity and availability of critical assets and in many cases, reduce the overall cost of maintenance in the long-term.

US patent assigned to BMT's innovation

BMT recently announced that DuraCluster, its innovative mining modification and repair scheme, secured exclusive

patent rights in the US. International patent rights for the DuraCluster modification scheme have already been granted in the global consultancy's key territories of Canada, Australia, South Africa and India.

With DuraCluster offering the highest levels of lifecycle support and optimisation of removal capacity at the lowest cost per tonne, the BMT dragline design scheme is one of the industry's most sustainable mining solutions. By combining a low risk methodology and offsetting problematic boom designs, the BMT DuraCluster modification allows operators to realise greater energy efficiencies.

By implementing the DuraCluster scheme, critical dragline boom performance and fatigue life of cluster joints on existing tubular dragline boom designs are substantially improved, allowing for a heavier-duty cycle by increasing payloads and/or reducing cycle times.

Proven to provide sustainable availability for all dragline assets with boom and mast tubular clusters, the flagship BMT DuraCluster design modification has enabled mining operators to realise reductions in machine downtime and maintenance costs related to dragline tubular structures. The DuraCluster scheme greatly improves the reliability of dragline booms, which ultimately enhances machine productivity.

First introduced in 2013, the DuraCluster design has been successfully implemented on several draglines across North America. These installations have proven DuraClusters' operational efficiencies, ease of installation and operational suitability for mining operators. In addition, this modification also minimises the risks to operators and maintenance teams when needing to lower the boom and undertake complicated weld repairs with limited access. It also dramatically reduces repair costs due to the improvements to fatigue performance of cluster joints. Earlier installations on the Bucyrus 1570 at Westmoreland Coal Company's Paintearth mine, successfully reduced operational downtime and machine outage costs. Within the US, BMT has also partnered with Warfab to supply the DuraCluster as a turnkey industrial solution, including outage mitigation management, boom movement and fabrication installation support.

Conclusion

Existing draglines have long booms consisting of numerous tubular chords with interconnecting lacings welded to the chords at cluster joints. As a result, stresses are concentrated at these cluster joints and over time, fatigue cracking becomes widespread. The DuraCluster modification allows lacings to be cut away from the chord, thus providing easy access to remove damaged or previously repaired material. The exposed chord can then be carefully inspected and the weld repaired fully before installing the plate. The design also significantly extends the fatigue life of dragline booms by removing the problematic design detail and improving load paths, consequently reducing the stress concentrations experienced. WC

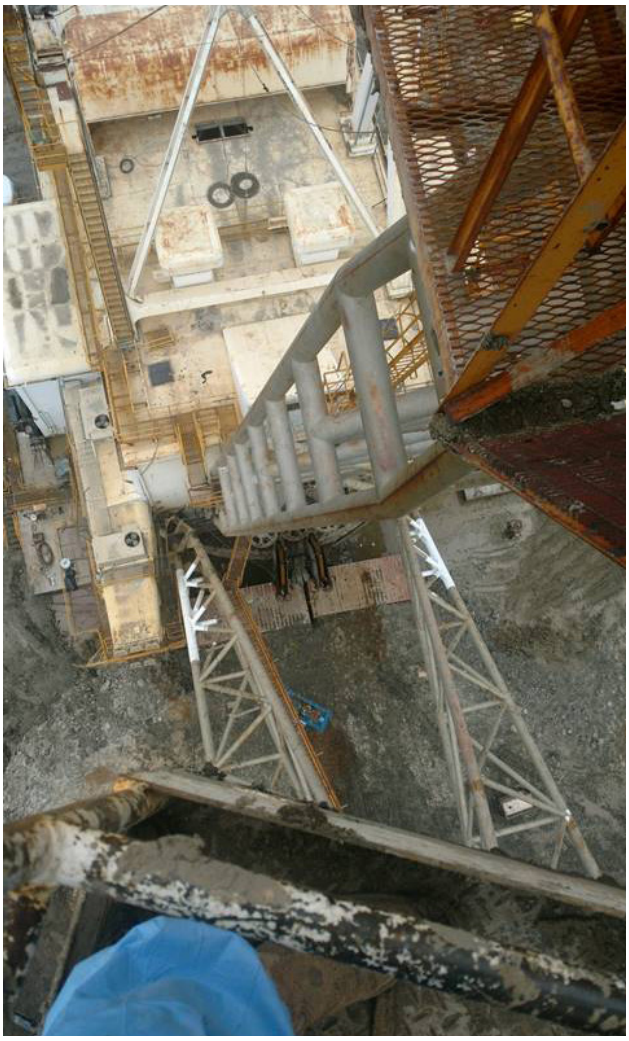

Figure 2. A view of the machine house from the top of the mast. The DuraCluster method can also be applied to the cluster joints on the mast.

Figure 3. DuraCluster removes the complex intersections associated with a traditional tubular joint design. Profile grinding and pneumatic impact treatment (PIT) of the weld eliminates micro-cracks associated with the heat affected zone at weld toe, and imparts a controlled compressive residual stress in the surface layer of the weld. Aside from the reduced stress concentration factors and stress associated with the DuraCluster design, these post-weld dressing techniques add additional weld life improvement, reducing operating risk and affording further protection against fatigue failure.