Develop and Test Alternative Conveyor Belt Cleaning Systems

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Abstract

This project aims to investigate, develop and test alternative conveyor belt cleaning systems to improve material handling operations at BHP Billiton Iron Ore Port Hedland. Most of the material that is transported on a conveyor is discharged at the head pulley, however a small proportion clings to the return belt resulting in the potential for spillage along the return length of the conveyor. The cost of this wasted product, damage to conveyor components and costs associated with handling this spillage are significant not to mention the environmental impact. It is for these reasons that belt cleaning has been focused on over the past few decades and extensive research into the integrity and effectiveness of belt cleaning equipment is beneficial to any materials handling operation.

1.0 Background

BHP Billiton's Iron Ore Port at Port Hedland is the largest iron ore Port in the world with over 140 conveyor systems. Constant maintenance is required on the conveyor systems due to belt wear, roller wear, and build-up of carry over material. Currently there are two main methods in place at BHP Iron Ore designed to reduce these problems by cleaning conveyer belts at the discharge end:

- Primary scrapers are applied on the head pulley and/or secondary scrapers applied either on or slightly past the head pulley and
- Belt wash systems - that consist of a series of scrapers and sprays in order to remove excess dust from the conveyor belt.

Systems installed are not always effective and have maintenance and adjustment problems, in particular maintaining scraper blade pressure against the conveyor belt, scraper wear and material build-up. Specific belt wash system problems include water blockages, jammed linkages and air bladder damage.

The project scope includes:

- Investigating the effectiveness of existing methods onsite and researching alternative methods for removing iron ore from conveyer belting.
- Examining adhesion forces of ore to conveyor belting and the reason for carry back.
- Designing and manufacturing or sourcing cleaning system/s for testing.
- Establishing laboratory rigs to assess performance of cleaning systems.
- Scaling up system/s and conducting site tests.

2.0 Problem Identification

2.1 Carryback Deposition

Carryback (material that adheres to the belt after the discharge point) is a result of adhesion that occurs at the material-belt boundary and cohesion between the material particles. A fraction of the carryback material adhered to the belt is subsequently deposited along the return length of the conveyor (Figure 1), mainly as a result of abrasion from return idlers and changes in belt orientation. Accumulation of carryback material is very costly and time consuming for clean-up and maintenance crews and presents a safety hazard to personnel around the plant.

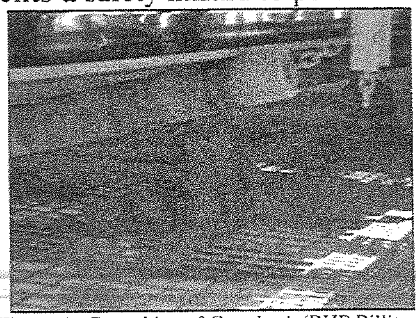

Figure 1 - Deposition of Carryback (BHP Billiton)

2.2 Dust

Airborne dust control is an environmental and safety requirement of any materials handling plant and certain dust levels are enforced. It has been shown (BHP Billiton 2003) that a reduction in carryback due to improved belt cleaner efficiency results in lower dust emissions from conveyors.

2.3 Idler Wear

As a result of the abrasive nature of carryback material, return idlers (Figure 2) experience an accelerated rate of wear. This can become problematic if idlers are not regularly replaced and the outer shell of the idler can be worn through causing a "potato peeler" scraping effect on the belt.

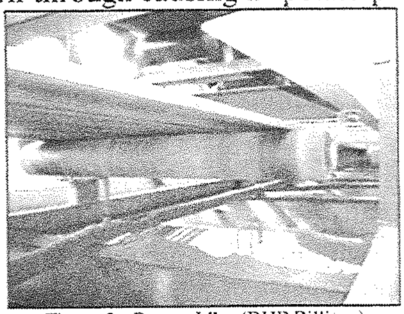

Figure 2 - Return Idler (BHP Billiton)

2.4 Belt Wear

In some cases where deposited carryback has accumulated to the extent that it is touching the belt, rapid belt wear will occur resulting in an unevenly worn belt profile and reduced service life.

2.5 Bearing Wear

One of the major causes of bearing failure on conveyors is wearing of the bearing support ring due to the build up of material on the bearings.

2.6 Mistracking

Belt mistracking (Figure 3) can occur due to the uneven nature of deposition and the adhesion of carryback material to return rollers. This results in other problems including improper loading, poor ore flow and wearing of conveyor supports due to belt abrasion.

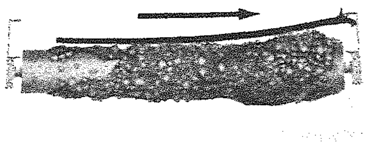

Figure 3 - Mistracking Belt (BHP Billiton)

2.7 Power

An accumulation of carryback on the belt can result in an increase in friction and, motors will require more power to drive the system.

3.0 Adhesion

During normal conveying, ore separates into three layers, a layer of wet fines against the belt, a coarser dryer material above the wet fines and then the larger ore lumps above that. Due to the porosity and nature of conveyor belt rubber, the fines material closest to the belt are adhered to the rubber by a combination of ore pressure, loading forces and vibration from travel. A percentage of this material usually remains adhered to the belt after ore discharge and after travel around the head pulley.

There are also electrostatic forces that contribute to adhesion of the fines to the belt, but these are extremely small in comparison to the 'mechanical adhesion' of the material in the pores of the rubber belting. The electrostatic forces can be overcome by wetting the belt.

Adhesion forces can be determined by using the the direct shear test (Figure 4) for conveyor belt and iron-ore and then extrapolating the resulting surface yield locus (Figure 5).

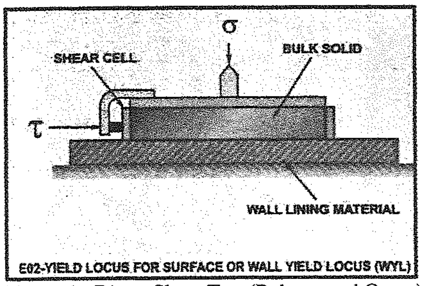

Figure 4 - Direct Shear Test (Roberts and Ooms)

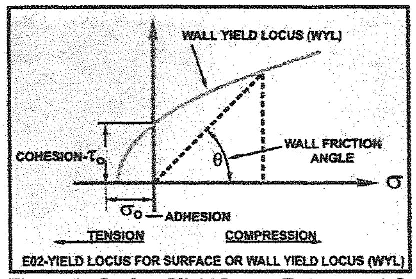

Figure 5 - Surface Yield Locus (Roberts and Ooms)

4.0 Cleaning Systems

4.1 Introduction

There is currently an enormous number of different conveyor belt cleaning methods both on the market and being researched. The intention of this project was to examine the feasibility of as many viable methods as practical and determine the best solution to the problem. The information below gives a general overview of the more common belt cleaning methods.

4.2 Current Systems

4.2.1 Scrapers

Scrapers (Figure 6) rely on linear contact with the conveyor belt in order to remove carryback material. Scrapers consist of single or multiple blades at different orientations (peeling, scraping, flat or angular), constructed from different materials (rubber, steel, ceramics, urethane or tungsten carbide), at different locations (head pulley or along the return belt) and attached to a contact adjusting device (spring, counterweight, air bellows or water bellows) to ensure that the blades apply constant pressure to the belt and to allow for transverse movement of the belt and wear of scraper blades.

A systems approach to cleaning using scrapers is most common, and usually a series of scrapers are mounted directly after the discharge point to remove material. The most common arrangement is a primary scraper followed by a secondary and sometimes a tertiary scraper. Other cleaning devices are sometimes mounted between scrapers including water sprays and rotary brushes.

Figure 6 – Side View Scraper + Mount (BHP Billiton)

4.2.3 Beater Rollers

Beater rollers remove material from the belt by vibration which is setup using an uneven return roller. The change in radius and the rotation of the roller result in high frequency beating of the return belt. A beater roller (Figure 7) in use at BHPIO Port Hedland consists of a typical roller with small rods welded at intervals around the circumference. Material removed is deposited into a large chute and washed down into a sump using water sprays. Beater rollers are easily installed in the place of existing rollers, and require little maintenance; however, the material that is removed is not deposited consistently and a large quantity of dust is produced.

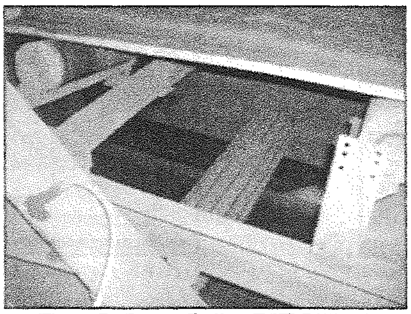

Figure 7 - Beater Roller (BHP Billiton)

4.2.4 Brushes

Both stationary strip brushes and driven rotary brushes (Figure 8) are used in conveyor belt cleaning applications. The rotary brushes are driven against the direction of the conveyor belt and the resultant abrasion from the bristles removes material from the belt.

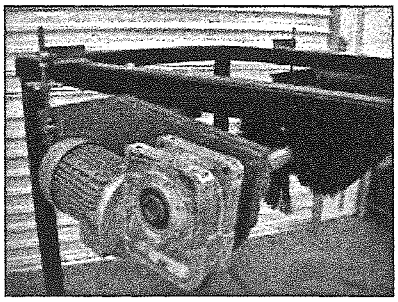

Figure 8 - Rotary Brush (Kinder)

4.3 Innovative Systems

4.3.1 High Pressure Water Jets

It has been found that the application of water to the belt prior to any scrapers increases the effectiveness of the scraping mechanism because it suspends the ore material on the belt allowing it to be removed more easily. Little research has been done into using high pressure water jets alone in order to directly remove material from the conveyor belt. There are obvious difficulties with this approach, such as the high volume of water required and the disposal and recycling of the resulting slurry material. However, the method requires little maintanence and is non-contact.

4.3.2 Steam Cleaning

Steam cleaning is commonly used for a number of industrial cleaning applications and it may be a viable alternative for removing carryback. It allows very high pressure to assist in removal and relies on minimal water application.

4.3.3 Chemical

Little research has been performed on chemical methods to assist in belt cleaning, including coatings to reduce the adhesion of ore to conveyor belt, fillers to reduce the porosity of the rubber, or detergents to assist in the cleaning process.

4.3.4 Vacuum/Compressed Air

Several researchers have concentrated on developing a non-contact vacuum or compressed air solution to remove material from conveyor belt. The advantage of this method is that the non-contact process causes little wear to mechanical parts. However, using compressed air produces large quantities of dust and, because of the ore's weight and strong adhesion forces, means that extremely high flow rates and pressures will be required.

5.0 Testing

5.1 Microscopy

In order to examine how the porosity of the conveyor belt rubber affects adhesion of ore material, it has been decided to use a Scanning Electron Microscope (SEM) to perform microscopy testing. Small circular samples of conveyor belt will be used for testing and microscopy photographs taken at each of the following three steps in the testing process (Figure 9).

1	⟶	2	⟶	3
Raw conveyor belt samples	Iron ore adhered to each sample at a given pressure to simulate causes of adhesion usually present onsite from overburden ore, loading and travel.	**Conveyor belt samples with adhered ore**	Each sample cleaned using a different cleaning system	**Cleaned conveyor belt samples**

Figure 9 – Testing

This methodology will obtain preliminary results to determine the effectiveness of a wide range of different cleaning mechanisms without extensive time consuming onsite testing.

5.2 Onsite

Cleaners will be mounted on high-use conveyors at Port Hedland making use of existing belt wash mounting frames. During times when the conveyors are in operation, cleaning systems will be started and tests performed using a carryback testing device (Figure 10). This device collects any remaining amount of ore left on the conveyor belt directly after it has been cleaned by the specific cleaning system.

The carryback tester operates using a high pressure pneumatic ram that forces three consecutive blades against the belt to remove material. A bucket captures the material scraped off by the blades and a final carryback mass per unit area can then be determined using conveyor speed and width. The bucket traverses across the width of the belt in order to obtain an average value.

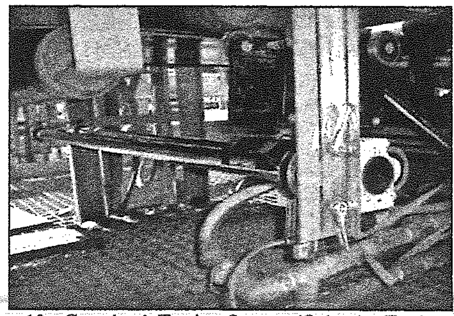

Figure 10 - Carryback Testing System (Oakpoint Engineering)

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