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Review of Conveyor Belt Monitoring Research in Australia

Dr A Harrison

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REVIEW OF CONVEYOR BELT MONITORING RESEARCH IN AUSTRALIA

A. Harrison
CSIRO Division of Applied Physics, Sydney, Australia 2070

1. INTRODUCTION

Belt conveyors play an important role in the handling of bulk materials in a number of primary industries. Research in Australia aimed at improving the reliability of belt conveyors in bulk materials handling systems has highlighted the need for belt condition monitoring as an integral part of the handling process.

Conveyor belts reinforced with steel cords fail during operation for various of reasons, including corrosion of the cords from hostile solutions, impact fracture of the cords, splice failure, wear and longitudinal tears. Though steel cord belts are generally confined to applications requiring high belt tensions, they also have applications as high-lift short belts for in-plant handling of particulate solids in the metaliferrons, coal and power industries.

This paper briefly reviews Australian research into methods for determining the condition of moving belts and describes techniques and instrumentation that have been developed for their non-destructive testing.

2. MONITORING PROGRAM

During the past five years a considerable amount of research and investigation into many of the problems facing the mining industry has resulted in the development of a range of advanced belt monitoring techniques. Many of these new technologies have been patented and some have been commercialised. The program of monitoring research includes:

(i) Steel cord conveyor belt monitor for corrosion detection [1,2,3]
(ii) Broken steel cord monitor [4,5]
(iii) Magnetic signature analysis of splice structure [6]
(iv) Splice failure detection by surface strain measurement [7]
(v) Splice condition monitoring by impulse testing [6]
(vi) Capacitive rip detectors [8]
(vii) Velocity and accelration monitors for stress analysis [9,10]

(viii) Development of magnetic reluctance probes [3,11]
(ix) Kevlar monitoring
(x) Remote monitoring by telemetry.

The last two areas of investigation are recent initiatives aimed at capitalising on the already existing monitoring experience sand expertise, while at the same time providing research into new materials and methods for monitoring. A brief description of some of these techniques follows.

3. BROKEN CABLE MONITOR

Figure 1 illustrates the cross-section of the monitor for detecting broken cables in moving steel cord belts. The coils are energised to provide a large magnetic field to magnetise the belt in one direction. This process, called pre-conditioning, erases spurious fields in the belts cables, while generating external fringing fields at cord ends and broken cords. A patent has been applied for [12] and licences are being sought to exploit this patent, through the CSIRO commercial company SIROTECH. This device is well suited to permanent installations. Field tests with such installations indicate that a trained operator could identify breaks from the output records or display and asses the rate of growth of broken and corroded cords. The structural layup of splices has also been tested with this instrument [6].

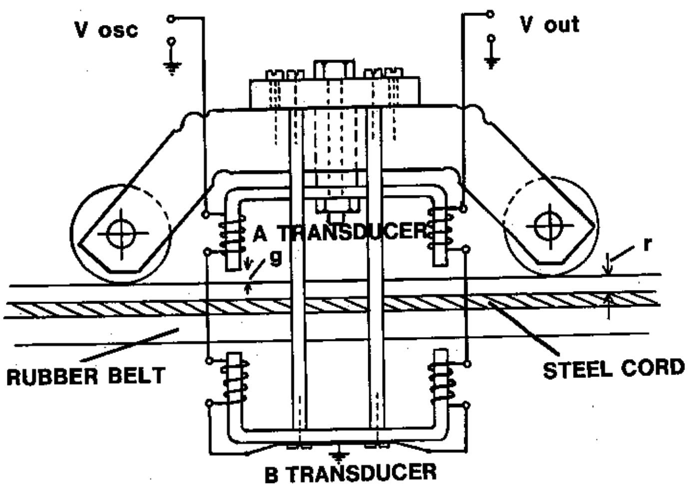

Figure. 1. Cross-section of the transducer used to monitor broken cables and steel-cord corrosion in moving belts. Idlers may be used to replace the wheel assembly shown if the moving belt is stable.

4. STEELCORD BELT MONITOR (CBM)

The apparatus described by figure 1 may also be used to directly measure corrosion. One set of coils is excited with current over a range of frequencies and the signal is sensed by the opposing set of coils. This signal depends on the reluctance of the cable path, and demodulation yields a voltage proportional to the mass of steel in the belt. The signal is placed onto a chart recorder. Due to the more exacting requirements of the electronics, permanent installations are generally less desirable than a periodic service scan of the belt. In practice, both broken cable signals and corrosion or mass signals are recorded simultaneously with special instrumentation such as shown in figure 2; the recorded signals are illustrated in figure 3. Considerable experience is required to accurately interpret signals from the CBM. In Australia, Nilsen Electrical in Melbourne has attempted to use microprocessors to analyse signals from moving belts [13,14], however, Conveyor Belt Monitoring of Sydney have captured a significant proportion of the market operating the CBM as a service. Belt tracking may be routinely monitored with the CBM [15].

5. MAGNETIC RELUCTANCE PROBES

The reluctance probe is a spinoff from the CBM research. The probe is portable and is used as a contacting sensor to measure distances to steel members which are embedded in a non-magnetic material [3,11]. The practical application of the probe is described by Brown [16]. The probe has applications to tyre testing, factory testing of steel cable belts, detection of reinforcing in concrete and measurement of non-ferrous reinforcing embedded in different materials by losses in the reluctance path caused by eddy currents.

6. SPLICE FAILURE MONITORING

The failure of conveyor systems through faulty or weak splices is a major concern to belt users. A number of new methods have been investigated in an attempt to assess the degree of adhesion in vulcanised splices. One method developed in 1982 [17] and tested with success in the field [7] relies on the measurement of distortion of a grid placed on the splice in low tension and remeasurement at high tension [6,7]. Figure 4 shows the distortion plotted as a contour map over the splice surface for a splice in which 1/3 of the area lacked adhesion [7]. The grid distortion method or straight-line technique has practical limitations in some situations, and to cover these cases other methods have been investigated.

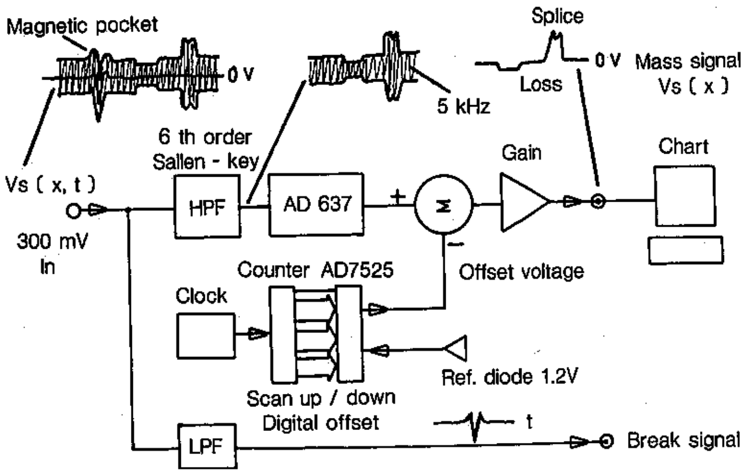

Figure 2. Processing instrumentation for separating steel cord.

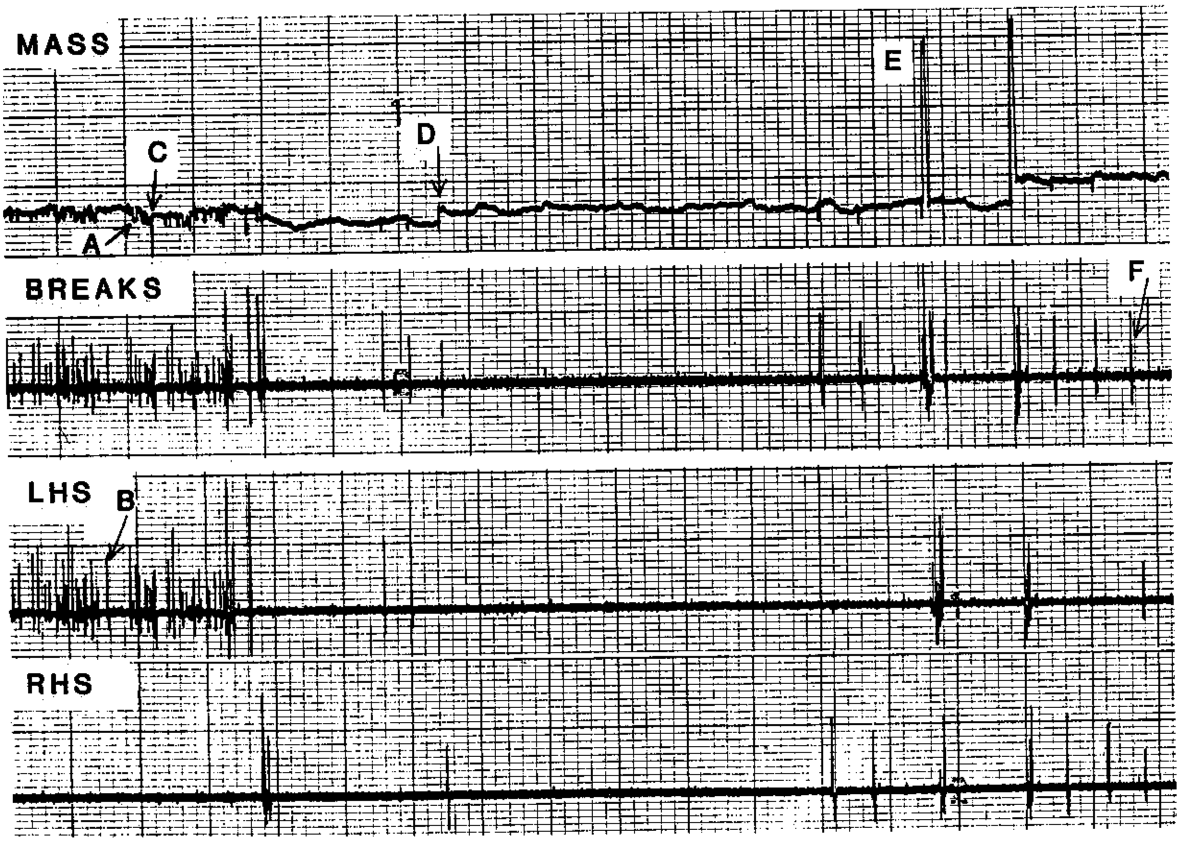

Figure 3. Mass and break signals for belt showing the following defects:

A – 1 cord missing for 1 m of length
B – Touching break
C – Corrosion
D – 1 edge cord increase on the right side
E – A splice
F – Broken cord in the centre

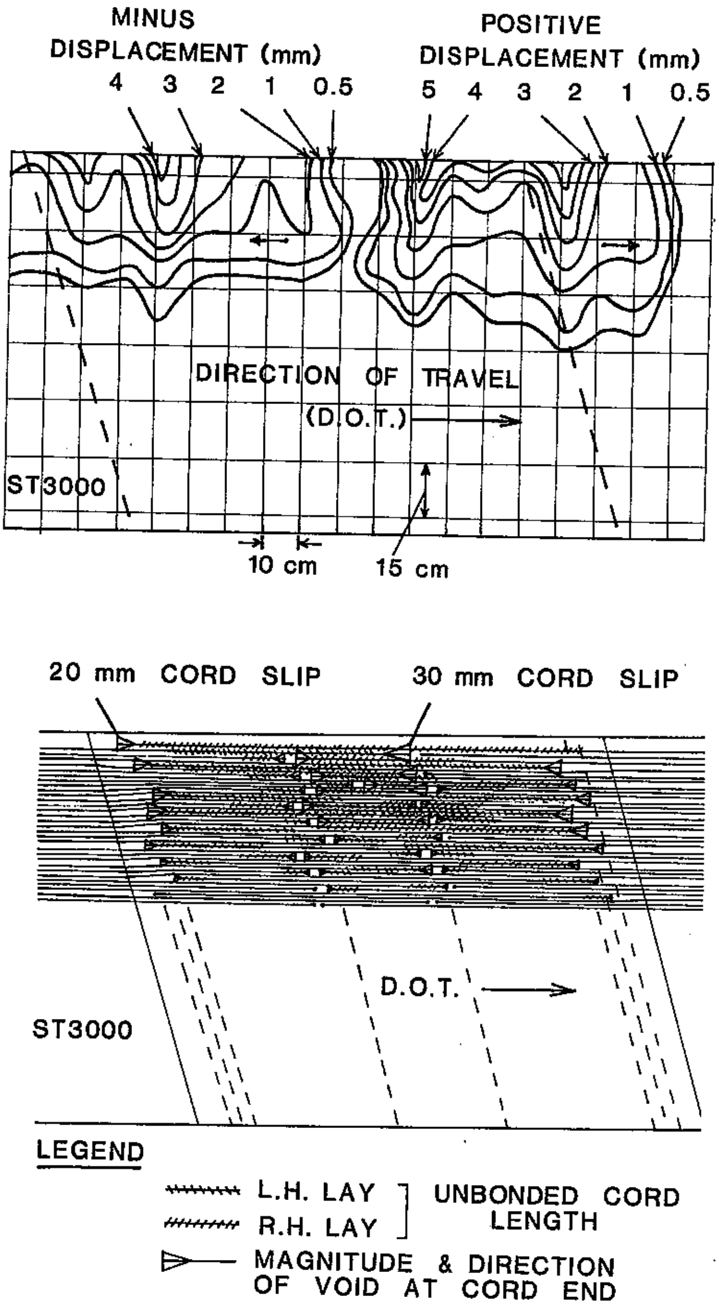

Figure 4.
Contour map of surface strain for a failing splice, together with the results of destructive testing to reveal the extent of debonded cables.

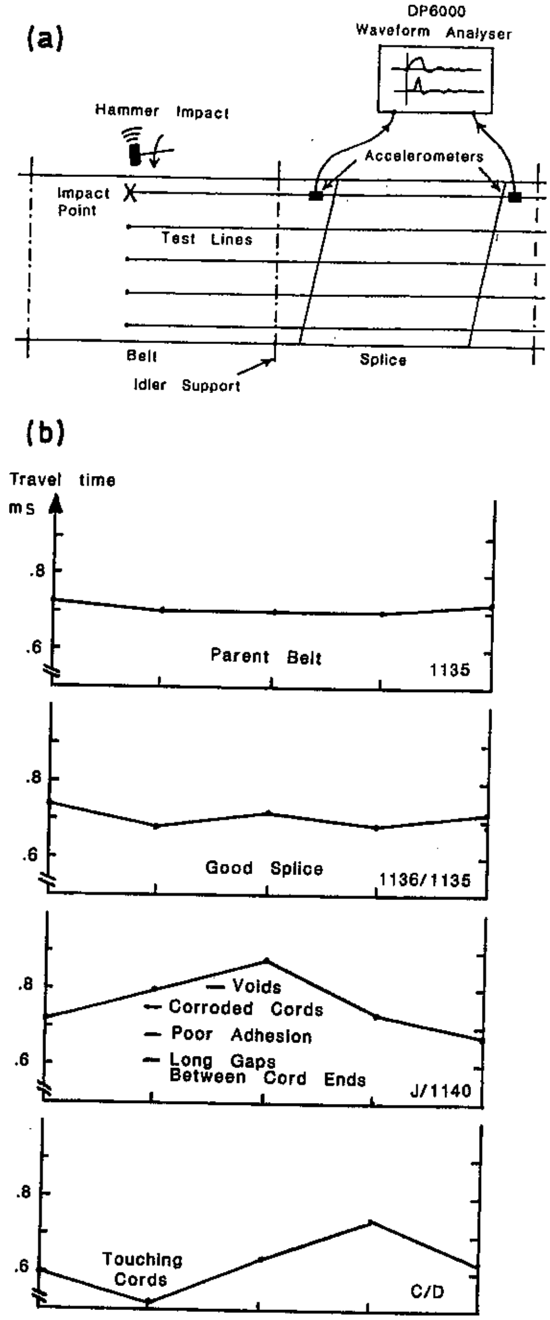

Figure 5.
(a) Method used to shock test splices [6].
(b) Profiles of shock propagation times for a variety of faulty conditions.

For example, a shock-testing method has been recently developed to overcome practical problems with splice testing [6]. Figure 5 shows the method in which accelerometers are used to record the time-of-travel of a shock-front generated by a hammer blow downstream from the splice. Destructive tests have been employed to correlate shock data with physical anomalies. The measurements can discriminate between near-touching cables in the splice and voids, corroded cords or poor adhesion.

7. SUMMARY OF OTHER MONITORING ACTIVITIES

Rip detection is a major problem to industry with expensive belts. A number of methods exist for detecting rips, including embedded loops in the belt. A capacitive system has been built and tested for rubber belts [8], though the results are not conclusive. J.B. Cunningham from Mt. Isa Mines [18] has patented an ultrasonic rip detector. Kevlar reinforced material is becomning increasingly accepted in industry. Methods for detecting the fracture of Kevlar are being investigated, together with application of the straight-line technique and the shock testing technique for evaluating splice condition. Monitoring signals over long distances by telemetry is being conducted under a CSIRO/University of Newcastle collaborative research agreement.

8. CONCLUSION

A review of belt monitoring activity in Australia has been briefly outlined. Considerable advances have been made in this area and a list of references is provided to enable further reading.

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