Summary

• Cross-belt cutter use
• Review of key links to the Standards
• Review of key items from ACARP Studies
• Problems around the use of cross-belt cutters with angular velocity variations
• An overview of the tool and development
• Overview of the fieldwork involved
• Case Studies
• Correcting issues relating to a cutter
Cross Belt Cutter Use

• Increasingly cross-belt sample cutters are being installed.
• Cross-belt sampler cutters are for obtaining samples of material while it is being transported on a conveyor belt.
• The cutter is moved across a conveyor belt as a means of taking a sample of the material on the belt.
• Easier to install initially or retrofit compared to falling stream samplers.
• Flexibility in location: Falling-stream cutters are located at the head of a belt.
Cross Belt Cutter Use (cont.)

• An earlier study\(^1\) concluded that cross-belt sample cutters cannot be trusted to produce unbiased samples and that uniformity of rotation is not particularly important, however that discussion is not for here and now.

1. Source: ACARP Project C15072, 2010
Cross Belt Cutter Use (cont.)

- There are different configurations:
  - A  Cutters travelling at 90° across a belt (Square Cutters).
  - B  Angled cutters to minimise bow waves (Skew Cutters).

- This presentation is concerned primarily with the ability to measure the velocity (and variation) of the sample cutter as it travels through the material on the conveyor belt, as described in the relevant standards.
Links To The Standards

• AS4264.1 2009 (Withdrawn) states for a cross-belt cutter that “the velocity shall not deviate by more than 10% from the average velocity.”

• The current ISO standard has no set tolerance from the average cutter velocity for a cross-belt sampler, however, ISO13909-2 2016 does state “it is undesirable to impose such strict limitations on cutter velocities as those applying to falling-stream samplers.”
• ISO 13909-2 – 2016 specifies that “the minimum cutter velocity shall be 1.5 times the belt velocity.”

• This standard also specifies “Irrespective of the cutter speed...cutters shall be shown to have minimise bias.”

• When operating at significantly varying speeds through a material stream, a cross-belt cutter may be introducing a sampling bias.
Problems With Speed Variances

• Introduction of bias: poor precision/accuracy of results.
• Maintenance considerations: additional cutter head wear if cutter slowing in the material stream.
• Spillage / housekeeping / safety aspects.
Overview of the Instrument and Development

• There are several instruments available for measuring falling-stream (linear) cutter velocities.
• Instruments developed for falling-stream cutters measure linear, or one dimensional, movement.
• A&B Mylec has not been able to identify a practical/field instrument available commercially for measuring cross-belt cutter velocities.
• Instruments for measuring cross-belt cutter velocities need to measure in several dimensions (as the cutters move in circular motion) so require a different technical approach.
Overview of the Instrument and Development

- Confirming rotational velocity of a cross-belt sampler is constant within tolerable variation.
- Instrument development managed by A&B Mylec.
- Enables measurement of velocity throughout the sample cut.
Overview of the Instrument and Development

- Sensors to obtain and record the required measurements using gyrosopes.
- Spatial measurement of cutter position and the rotational velocity at each point.
- This instrument can be attached to the cutter or drive shaft to collect relative velocity measurements at set time periods (2 milliseconds) as the cutter completes a full 360° rotation and passes through the material stream.
Using the Instrument in the Field

Attach Sensor to arm of the cutter, to measure the speed, positioning and angular velocity at all points during a full revolution (360°) of the cross belt cutter.
Using the Instrument in the Field (cont.)

- This device can also be attached to the drive shaft
Results Review – Case Study 1

• The velocity of the cutter was measured at each point of the cutter operation/rotation.

• Several cuts were completed with coal off (belt unloaded).

• Several cuts were completed with coal on the belt.

• Some tolerable velocity variation control limits were assigned:
  – +/- 5% = green dashed line
  – +/- 10% = red solid line
Results Review – Case Study 1 (Belt Unloaded)

Velocity Profiles of the Primary Cutter with No Material on Belt

- **Cutter Opening Enters Stream**
- **Cutter Fully in Stream**
- **Cutter Midway Across Belt**
- **Cutter Opening Exits Stream**
- **Cutter Exits Stream**

Cutter Speed (m/s)

Cutter Angular Movement (Degrees Relative to Cutter Start Position)

- **Run 1 (Feed Off)**
- **Run 2 (Feed Off)**
- **Run 3 (Feed Off)**
- **Average Cutter Speed (in Stream)**
- **+/- 10%**
- **+/- 5%**
Results Review – Case Study 1 (Belt Loaded)

Velocity Profiles of the Primary Cutter with Material on Belt

- **Cutter Opening Enters Stream**
- **Cutter Fully in Stream**
- **Cutter Midway Across Belt**
- **Cutter Opening Exits Stream**
- **Cutter Exits Stream**

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**Cutter Angular Movement (Degrees Relative to Cutter Start Position)**

- **Run 1 (Feed on)**
- **Run 2 (Feed On)**
- **Run 3 (Feed On)**
- **Average Cutter Speed in Stream**
- **+/- 10%**
- **+/- 5%**

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**Cutter Speed (m/s)**

- 12
- 11
- 10
- 9
- 8
- 7
- 6
- 5
- 4

**Cutter Opening Enters Stream**

**Cutter Fully in Stream**

**Cutter Midway Across Belt**

**Cutter Opening Exits Stream**

**Cutter Exits Stream**
Results Review – Case Study 1

• When there was no coal on the belt the cutter completed a cut at an average velocity which aligned to the design velocity, typically within +/- 10% of the average.

• When there was coal on the belt the cutter completed a cut at an average velocity slower than the design, velocity and at points was significantly slower than the design or average velocity.

• A fundamental principle of sampling is that particles have an equal opportunity to be included or excluded from the sample.

• Cutter velocity variations may result in an unequal opportunity for particles in the material stream to be sampled.
Results Review – Case Study 2

• The velocity of the cutter was measured at each point of the cutter operation/rotation.
• Several cuts were completed with coal running on the belt.
• Tolerable velocity variation limits assigned in the figure were:
  – +/- 5% = red solid line
Results Review – Case Study 2 (Belt Loaded)

Velocity Profiles of the Primary Cutter with Material on Belt

Cutter Opening Enters Stream

Cutter Fully in Stream

Cutter Midway Across Belt

Cutter Opening Exits Stream

Cutter Fully in Stream

Cutter Midway Across Belt

Cutter Opening Exits Stream

Cutter Exits Stream

Run 1 (Feed on)

Run 2 (Feed On)

Run 3 (Feed On)

Run 4 (Feed on)

Run 5 (Feed on)

Run 6 (Feed on)

Average Cutter Speed in Stream

UCL for Speed

LCL for Speed
Results Review – Case Study 2

- When there was coal on the belt the cutter completed a cut at an average velocity slower than the design velocity.
- In the second half of the cut the velocity slowed measurably.
- The brake was being applied when the cutter was still in the material stream.
- This can cause a wear issue on the cutter head, spillage and possibly a loss of sample.
Using the Information to Enhance Cutter Precision

• Identify sample cutters for bias testing to quantify the impacts on sample precision and accuracy identified by a primary cutter speed variation.
• Identify need for change in motor and gearbox size/design (e.g. higher torque system allowing cutter to traverse the material stream at a relatively consistent speed)
• Identify need for adjustment of braking
Using the Information (cont.)

• Identify points during the traverse in which the cutter may be interacting with the belt contrary to the intended design/operation

• Identify velocity variations contributing to bow waves, which can result in:
  – Damage/wear to the cutter head
  – Spillage/Housekeeping issues
  – Sample bias
Why Should I Care?

Lack of measurement precision results in decision uncertainty

Production and CHPP Operation:

- Make a density change?
- Is this the true quality on the stockpile?
- Adjust operating settings?
- Initiate a maintenance task?
- Do I need to modify a blend?
- Should I wait for the next result?
- Should I be conservative?
Why Should I Care?

- Measurement bias leads to conservative operational targets

### Assuming Conservative Production Ash Targets...

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Summary

1. Cross-belt cutters are increasingly being used at CHPPs due to ease of installation and cost.
2. It had not been possible to measure the velocity and velocity variations at which cross-belt cutters are operating at in the field.
3. The velocity is important to ensure that a bias is not being generated by a sampler.
4. The unit can assist in identifying regions in the trajectory of the cutter where there is an issue which can lead to an unequal opportunity for particles throughout the stream being included / excluded from the sample.
5. Lack of precision and accuracy in measurement systems significantly impacts good decision making and prevents achieving optimal revenues.
QUESTIONS

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