Case Study: Offset Idler Rolls Eliminate an Idler Junction Failure in Solid Woven PVC Belt

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Abstract
A 6.26 km longwall retraction conveyor transporting 4500 tph of coal on a 1600 mm solid woven PVC belt experienced severe bottom cover delamination along the idler junction soon after commissioning. Replacing the belt and modifying idler geometry did not resolve the issue. Conveyor Dynamics, Inc. (CDI) investigated the cause and used finite element analysis (FEA) to model the belt's orthotropic behavior and junction strains. Results showed that the inline 5-roll idler configuration produced peak junction strains exceeding 3.5%, initiating fatigue-driven delamination. Changing to an offset 5-roll configuration reduced the peak strain to below 2.5%, a 29% reduction, and distributed strain more evenly across the cover. After the offset idlers were installed, no further failures occurred through the end of the conveyor's service life. The study establishes a practical strain limit for solid woven PVC belts and highlights the reliability benefits of offset idler configurations.

Keywords
Solid Woven Conveyor Belts — Idler Junction Failure — Offset Idler Rolls

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1. Introduction

In 2015, Conveyor Dynamics, Inc. (CDI) was contacted by the operator of a 6260 m long Longwall Retraction Conveyor that transported 4500 tph of coal on a 1600mm wide belt. The conveyor structure was configured with 3m carry idler spacing, using a 5-roll catenary carry idler arrangement. This system included drives at the head, and two fixed tripper drive stations. The belt on this conveyor was a solid woven PVC belt with a breaking strength of 1750 N/mm. Shortly after commissioning this conveyor the bottom cover of the belt delaminated along its entire length at the junction between the center and lower wing rolls. The operator tried replacing the original belt with belts from three other manufacturers. All suffered the same failure at varying degrees.

Idler configurations were changed, to reduce the idler gap and provide a ridged idler configuration. The fixing of the idler joints and closing of idler gaps reduced the rate of catastrophic failure of the belt (splitting) but did not provide an acceptable solution long term.

CDI investigated the junction failure and recommended modifications to the conveyor to resolve the issue. Following CDI's recommendations, the operator changed the idler rolls from an inline 5-roll assembly to an offset 5-roll assembly. An inline idler set is an idler set in which all the rolls share a common centerline when viewed in plan. Inline assemblies always contain a gap between adjacent rolls. An offset idler set is a set in which the centerlines of alternating rolls are offset in plan. Typically, adjacent offset rolls overlap when viewed from the front of the set and no gap between the rolls is present.

After replacing the inline idler sets with offset idler sets, no further junction failures were detected between the time the modified idler frames were installed and May of 2019 when mining of the block this conveyor serviced was complete. This paper discusses the testing and simulation work used to support the change to offset idlers and the benefits offset rolls provide to conveyors.

2. Idler Junction Failure

Figure 1 and Figure 2 show the failing bottom cover of the belt in the idler junction of the belt on the longwall retraction conveyor. Figure 3 shows a cross-section of this belt supported by its original inline idler assembly. When this cross section was removed, the cover of the belt was just beginning to delaminate from the carcass. The failure in the junction begins as cover delamination, not cover wear. Since the failure took thousands of cycles to appear, we concluded that the delamination is a fatigue process. All belt manufacturers with product installed on this conveyor produced reports showing that the top and bottom covers of their solid woven belts met Australian Standard AS1334.7's minimum ply to carcass adhesion requirements in the longitudinal and transverse directions. Standard ply adhesion tests measure the force required to peal the cover of the belt away from the carcass. This test generates a very high localized non-uniform strain in the cover (Figure 4). The strain levels generated in this test are much higher than the strains found in the longwall retraction conveyor. Failure in AS1334.7 is achieved in a single pull not a fatigue process. None of the local or international standards we reviewed provide any guidance on the maximum acceptable idler junction strain, which is clearly much lower than the strain in the single pull test.

Figure 1. Bottom Cover Idler Junction Failure in Longwall Retraction conveyor

Figure 2. Roll of belt removed with a split in excess of 100m

Figure 3. Longwall Retraction Conveyor Belt on Inline 5 Roll Assembly

3. Calibrating a Finite Element Model of Solid Woven PVC Belt

The belt is a highly orthotropic material and the warp direction (parallel to the direction of travel) is much stiffer than the weft direction (perpendicular to the direction of travel).

In the warp direction, we assumed the elastic modulus of the carcass matched the ISO-9856 tested "Elastic Modulus" value reported in the belt datasheet. In the weft direction we obtained the modulus by adjusting the modulus of FEA elements until a simulation of a 3-pt bending matched (Figure

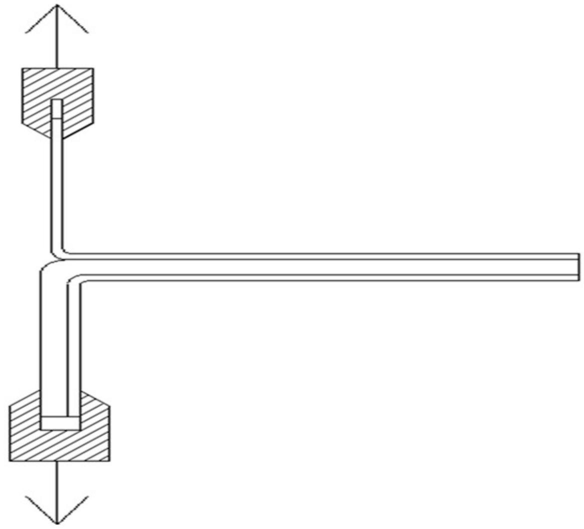

Figure 4. AS1334.7 Ply Adhesion Test Schematic

5) the actual test results on a 3-pt bending machine (not shown). Using this method, we determined that the FEA will predict the bending strain in this belt correctly when the modulus in the weft direction is 250 MPA and the modulus in the warp direction is 1874 MPa.

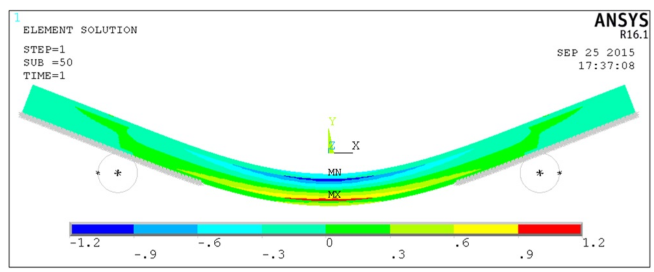

Figure 5. FEA Simulation of 3-pt bend test

4. Finite Element Model of the Longwall Retraction Conveyor Belt

CDI modelled the Longwall Retraction Conveyor's belt trough with a 45100 element ANSYS FEA model arranged as shown in Figure 6. Symmetric boundary conditions were defined on the centerline of the idler set and halfway between two idlers sets. The model assumes an orthotropic carcass material surrounded by isotropic covers. Initially, the belt is flat. Strain in the belt develops as the idler rolls rotate into position and then material load is applied (Figure 7). CDI used this model to explore the impact of various modifications to the idler trough.

5. Eliminating the Junction Failure

The Von-Mises strain at the interface between the bottom cover and the carcass of the original belt on the longwall retraction conveyor is shown in Figure 8. The peak strain in the junction was above 3.5%. Changing the idler rolls from

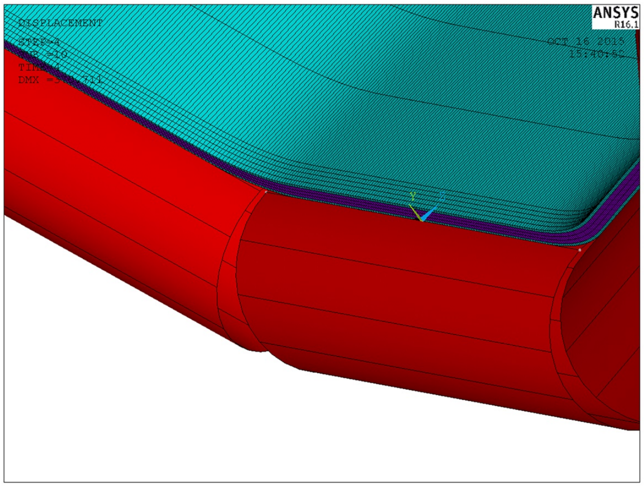

Figure 6. Initial Mesh

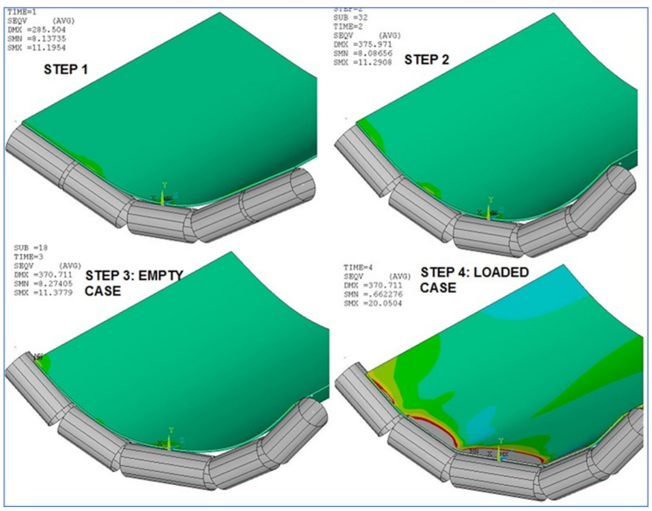

Figure 7. Simulation Steps

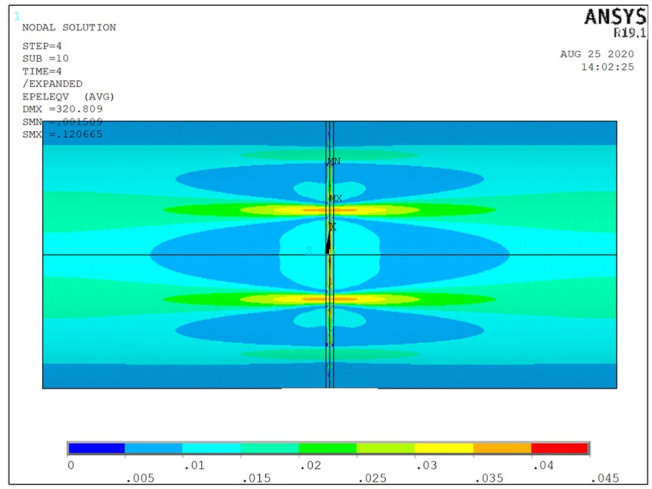

Figure 8. Von Mises Strain in the bottom cover of the original longwall retraction conveyor. Peak Strain in junction is exceed 3.5%.

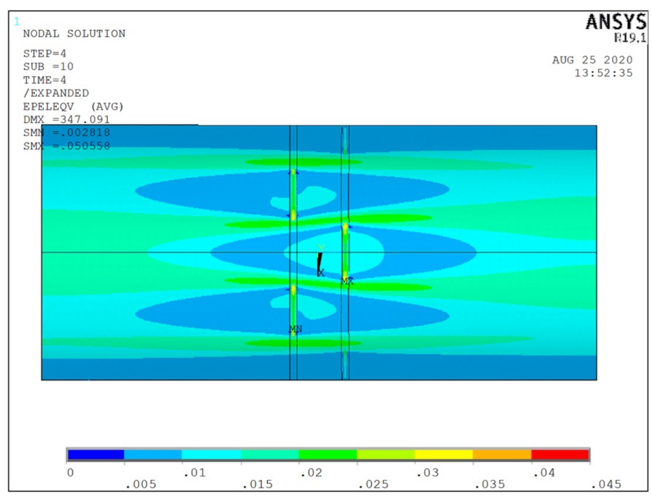

Figure 9. : Von Mises Strain in the bottom cover of the longwall retraction conveyor with offset rolls. Peak Strain is less than 2.5%.

inline to offset rolls reduced the peak elastic strain to less than 2.5%, a 29% reduction and dispersed the strain more evenly through the cover (Figure 9). By 2017, all inline rolls were replaced with offset idlers and no further junction failures were observed. This study establishes the allowable strain in the idler junction in solid woven PVC belt, which can serve as an important reference for future applications.

6. Conclusion

As belts become more heavily loaded, and idler spacing is extended to reduce conveyor cost, idler junction failures are become more common [Zhang, 2015]. This work clearly shows that offset rolls allow wide idler pitch in conveyors to function reliably, but advanced analysis techniques are required to avoid costly belt failures.

References

[Zhang, 2015] Zhang, Y. (2015). Conveyor belt bottom cover failure from idlers and pulleys. *IMHC Beltcon 18*.