A Finite Element Analysis on the Troughed Belt Turnover

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DESIGNERS OF BELT CONVEYOR SYSTEMS

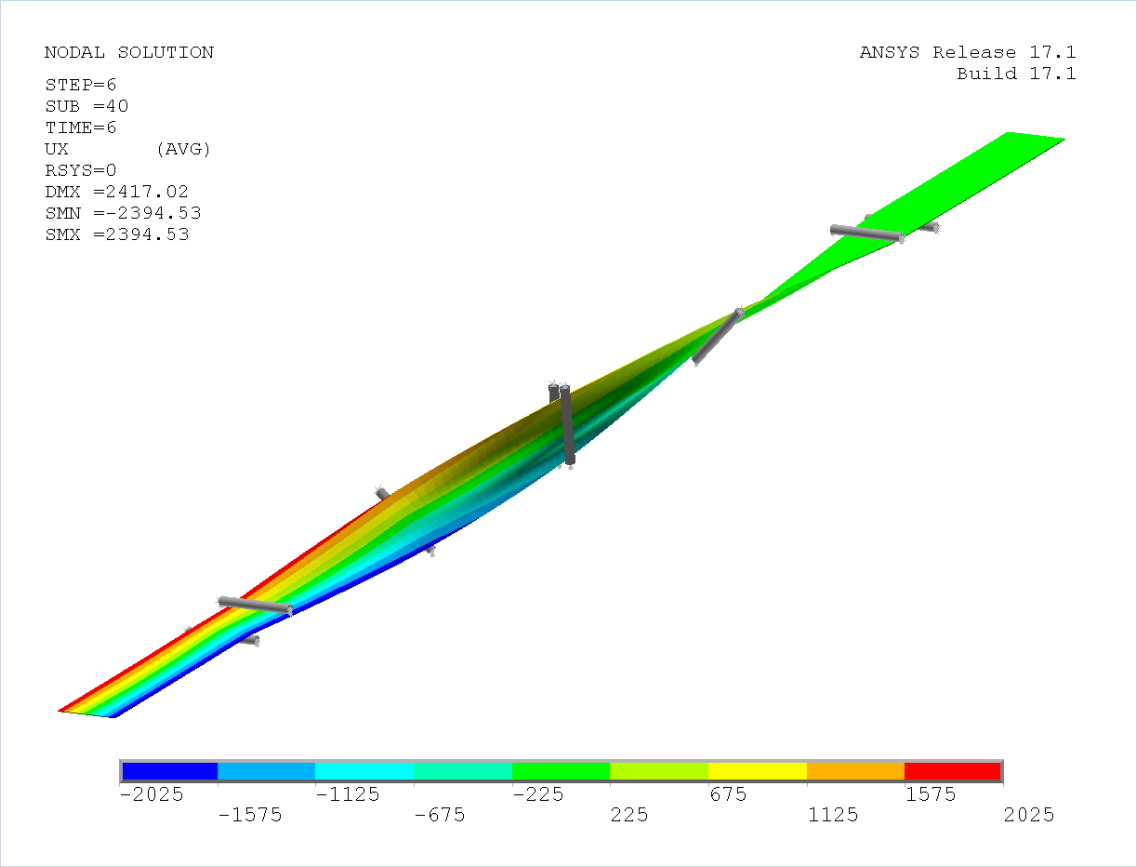
About CDI

Conveyor Dynamics Inc. is an engineering consulting company founded in 1981. Our focus is :

- Overland trough and pipe conveyor engineering
- Conveyor design software
- Advanced conveyor control/commissioning
- Instrumentation / Diagnostic Analysis/Failure Analysis
- Conveyor upgrade and de-bottlenecking
- Material transfer design and optimization using Discrete Element Modeling
- Conveyor component design and analysis (chute, pulley, belt, idler, structure, including belt turnover)

What is a Belt Turnover

Belt turnover system flips the belt on the return side, so that the dirty side is facing upward, and material carry-back is eliminated.



Why Belt Turnover

- Modern belt cleaning system is very effective, but couldn't prevent material carry-back 100%

  0.001% of carry back from 10 million tons transported in a year is **100 tons**

Flat Turnover



Pros:

- Simple and reliable
- No adjustment and tweaking needed
- Well studied and has design tool available through software like Beltstat

Cons:

- Needs large space
- Needs long turnover length (20 to 35x belt width)
- Higher stress and belt sag in the turnover
- Belt tends to buckle in the center

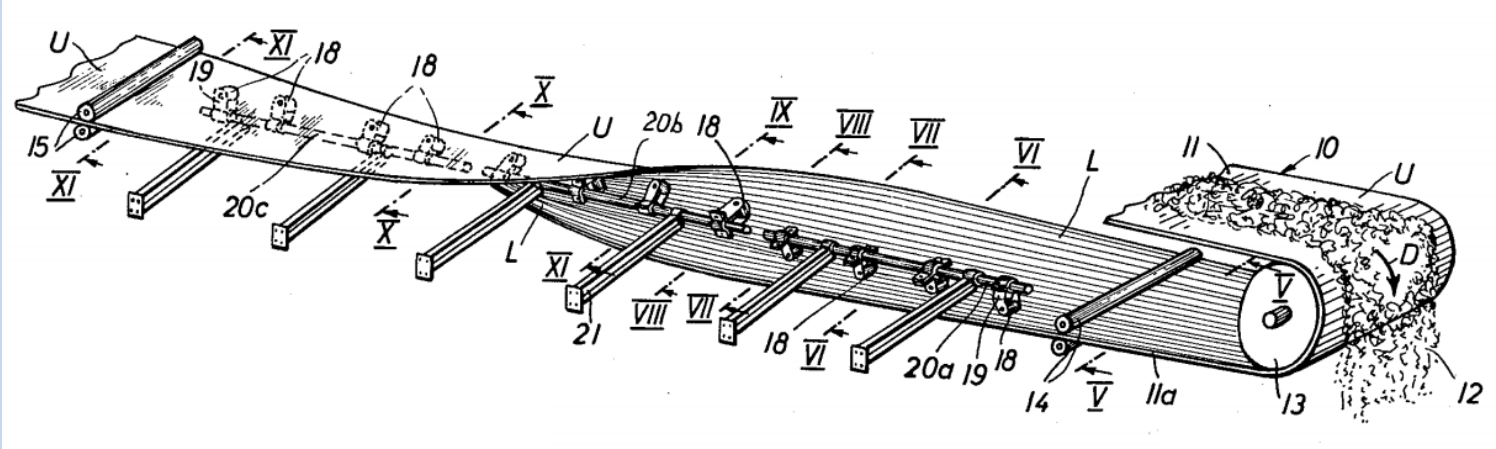
Where Belt Turnovers Are Applied

- Small plant conveyors usually don't use turnovers, because of cost, arrangement complications, and space requirement.
- Belt turnovers are more often used on overland conveyors.
- *Underground conveyors usually don't use turnovers, because of space requirement.*
- *Some large conveyors with wide belt (>2m/78") and very high rating (>ST5000) also forgo belt turnovers, due to concern of turnover length and belt stress.*

Center Buckling in Flat Turnover

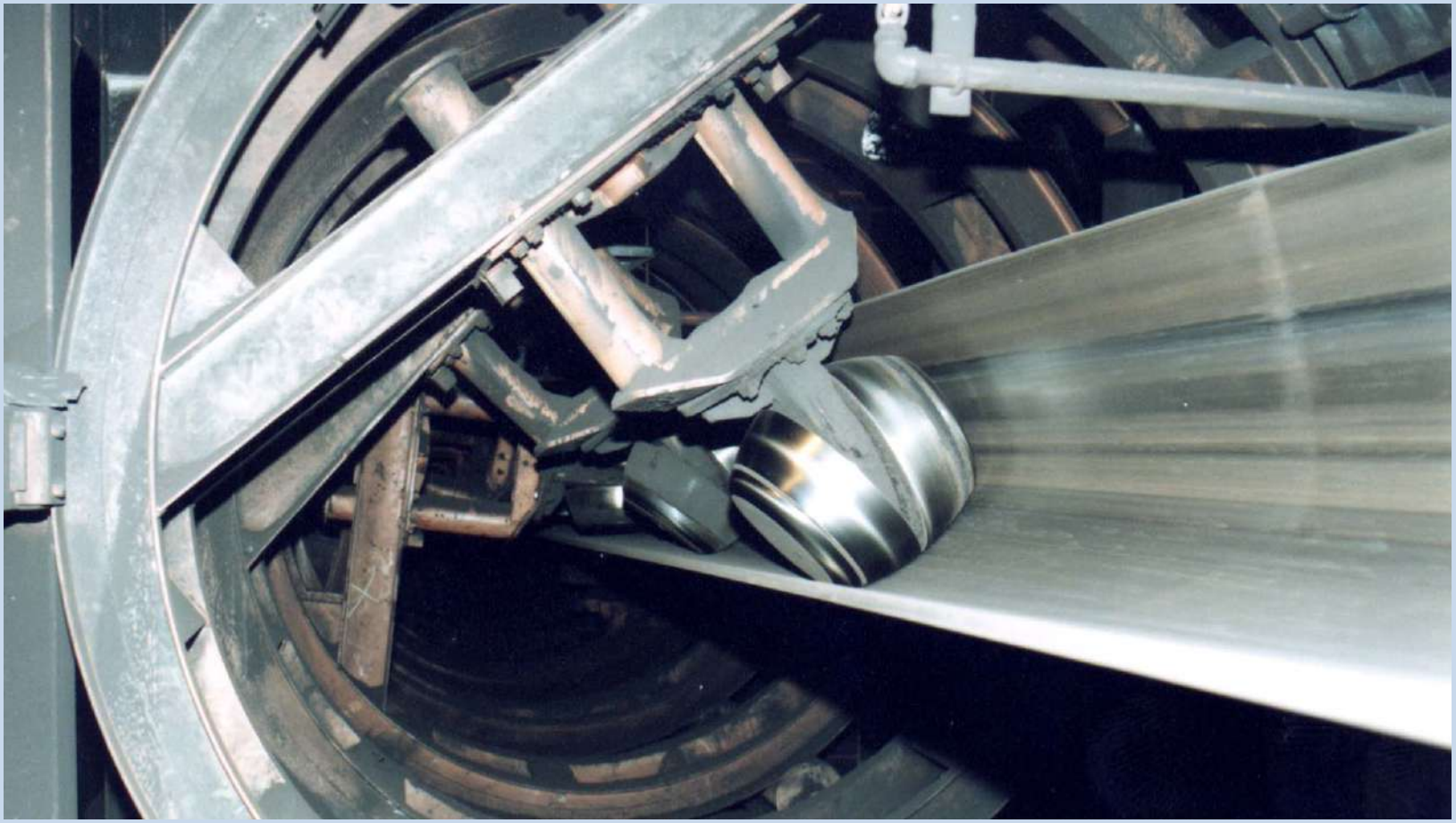
- Poorly designed (mostly being too short) flat turnover can have very high edge stress, compressive center stress, and a buckled shape.

Troughed Turnover



- Troughed turnover is pioneered by Walter Mordstein in 1960s.
- Different design variations were developed over the years. Also called supported turnover.
- Multiple guide rolls along the axis the belt trough to support and guide the turnover.

Example of Troughed Turnover



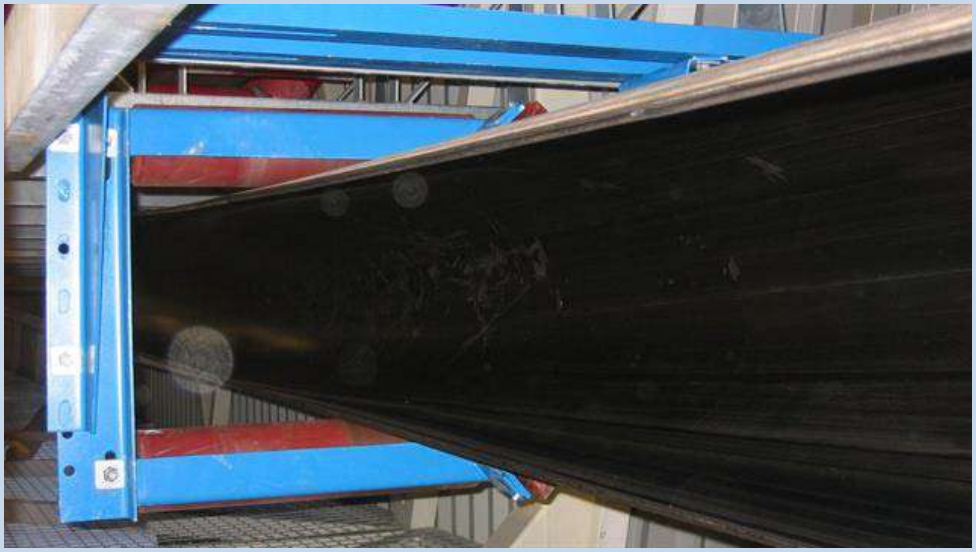
Example of Troughed Turnover

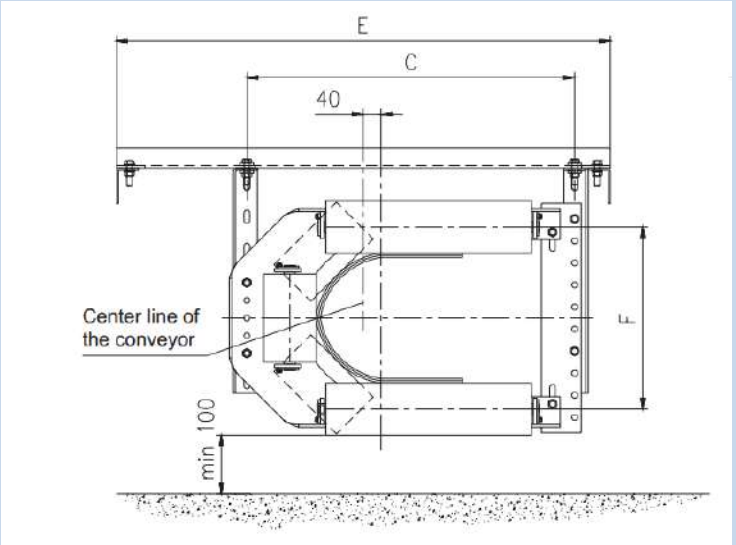
- **Too many degrees of freedom!**

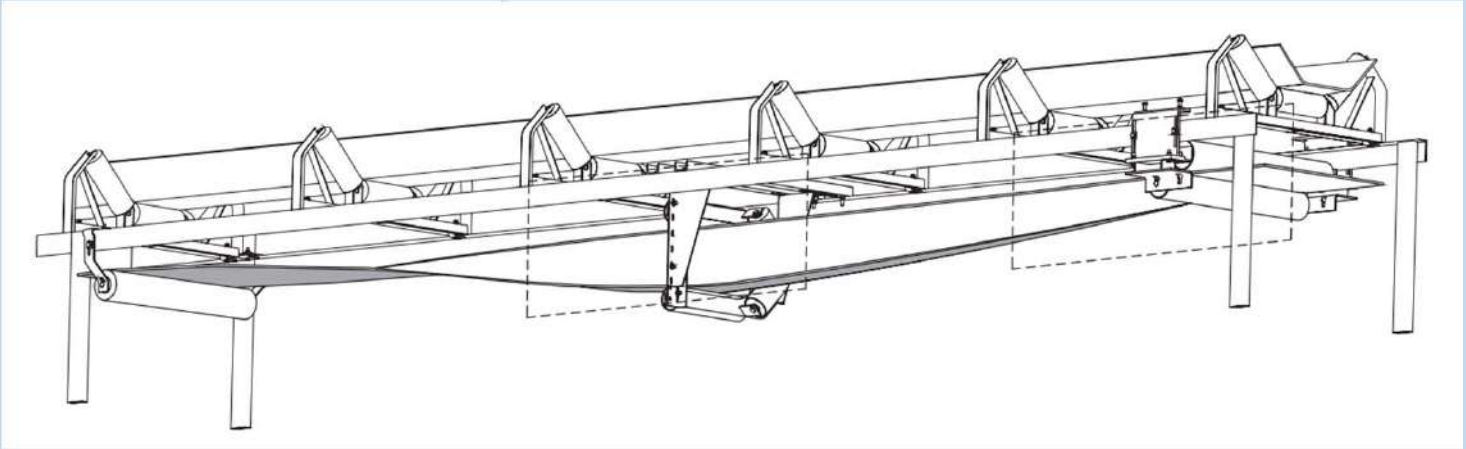
Example of Troughed Turnover

- Most troughed turnover has support and guide rolls inside, contacting the dirty side. But there are also designs with support rolls on outside bottom cover.

Example of Troughed Turnover: Sandvik







Troughed Turnover

Pros:

- Shorter turnover length
- Small profile and less space required
- Less stress in belt edge
- Less buckling in the center

Cons:

- Complicated arrangement
- Adjustment/tuning needed for some designs
- Very limited study and design tools available

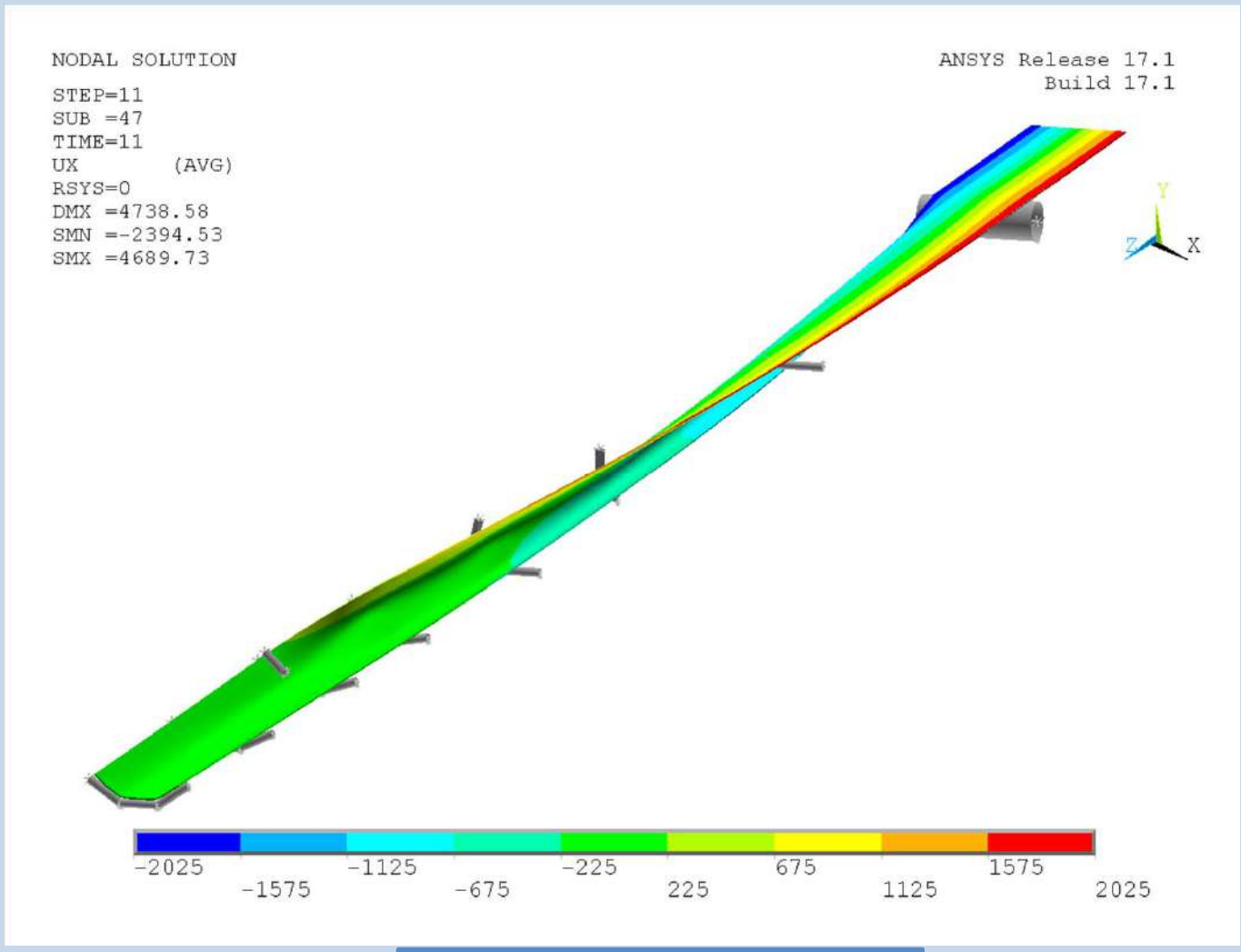
- The purpose of the study is to verify the claimed benefits of troughed turnover, establish an analysis tool, and offer some preliminary optimization

Parameters of the Belt and Turnover in this Study

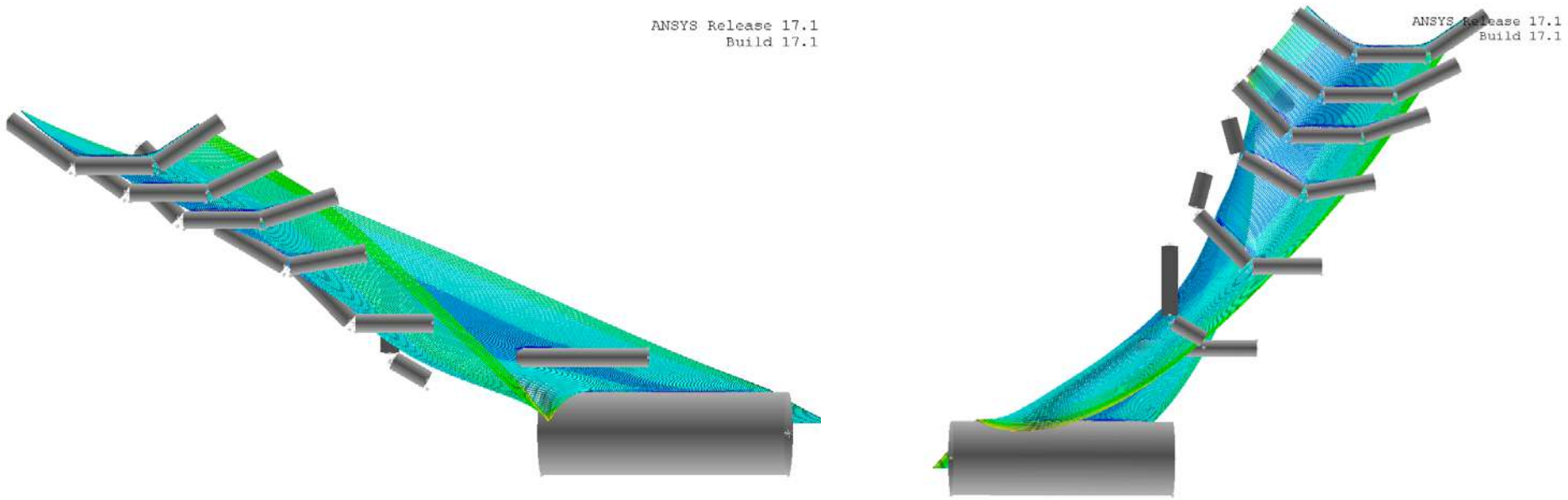
- Finite element analysis (FEA) is done on a flat turnover and a troughed turnover, with the same belt specification and belt tension. So two turnovers can be compared directly.

Belt Width	2000mm (78”)	**Steel Cord Pitch**	19.5mm
Belt Strength	ST-5200	**Cover Thickness**	10×8
Cord Diameter	11mm	**Belt Weight**	109 kg/m (73 lb/ft)
Steel Cord Break Tension	104kN (23.4 kips)	**Number of Steel Cords**	100
Steel Cord Ultimate Stress	1094MPa	**Belt Modulus**	372537 kN/m
Flat turnover Length	48m (157’) (24 × Belt Width)	**Belt Tension at Turnover**	Belt Safety Factor 25 (416 kN)
Troughed Turnover Length	36m (118’) (18 × Belt Width)		

Improved Troughed Turnover

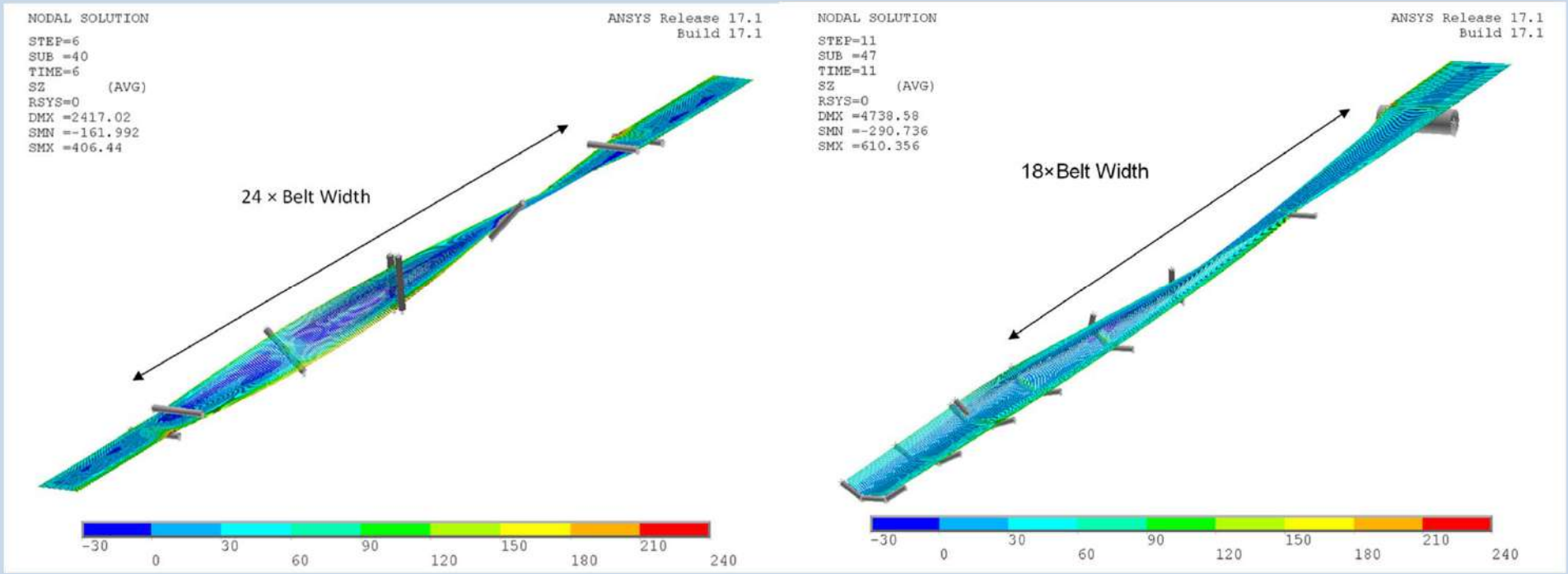


Advantages in the Proposed Design



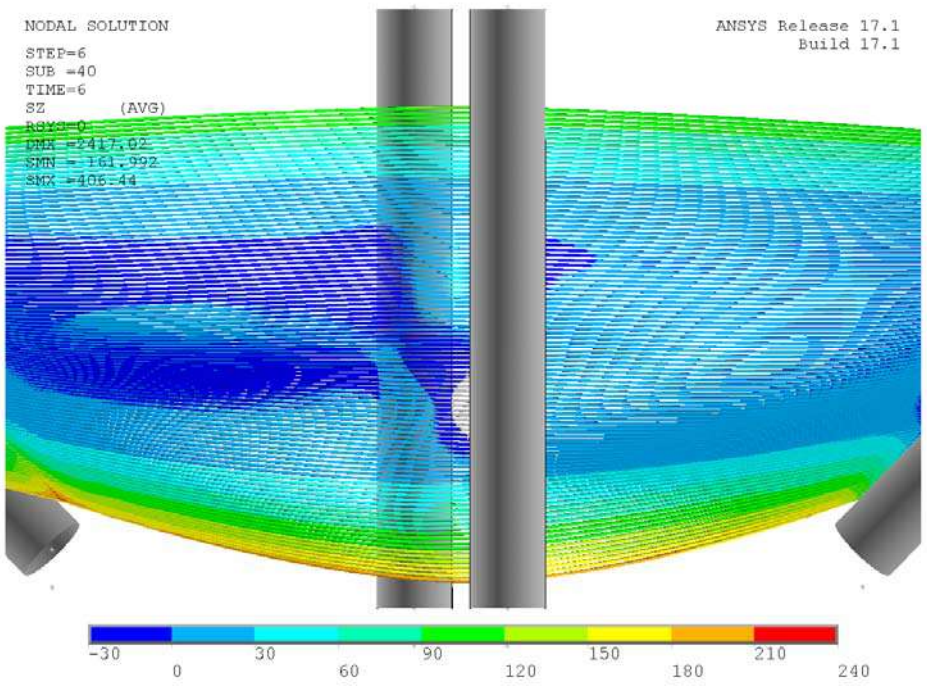
- Use trough rolls as guide rolls, instead of finger rolls or spherical rolls, to minimize cover wear
- Minimal adjustment is needed after installation; turnover arrangement is analyzed and optimized during design phase;
- Belt in trough shape at one end of the turnover and in flat shape at the other end, reducing the turnover length and simplifying pulley arrangement.
- Turnover profile and length are reduced compared to flat turnover.
- Stress in Belt is improved compared to the flat turnover.

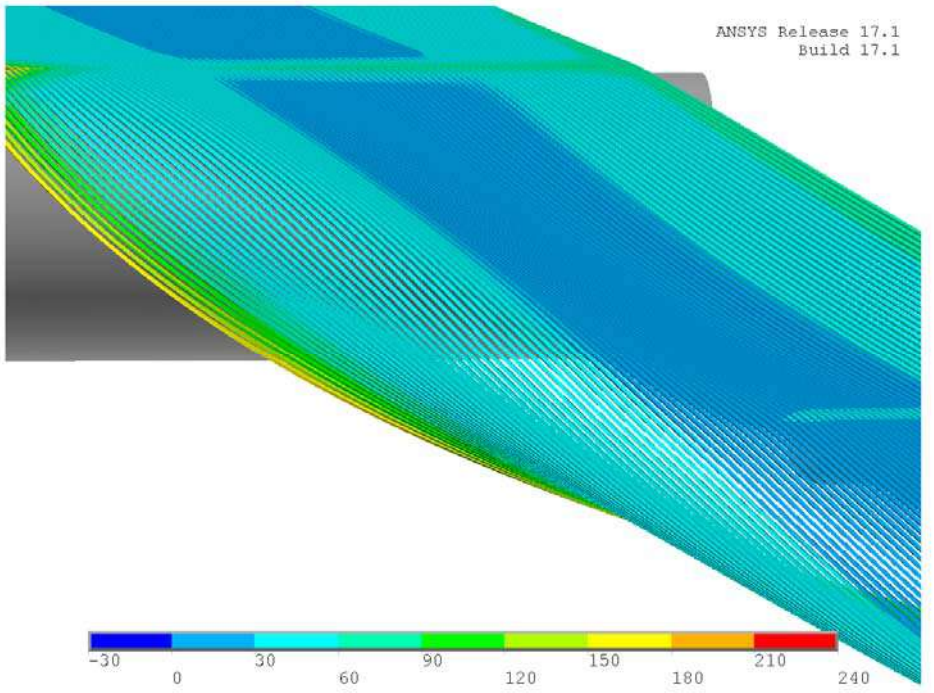
Comparison of Two Turnovers



- Flat turnover length is 24x Belt Width; Troughed turnover is 18x Belt Width (25% shorter);
- Belt edge stress is lower in troughed turnover.
- Belt center stress is higher in troughed turnover (less tendency to buckle)

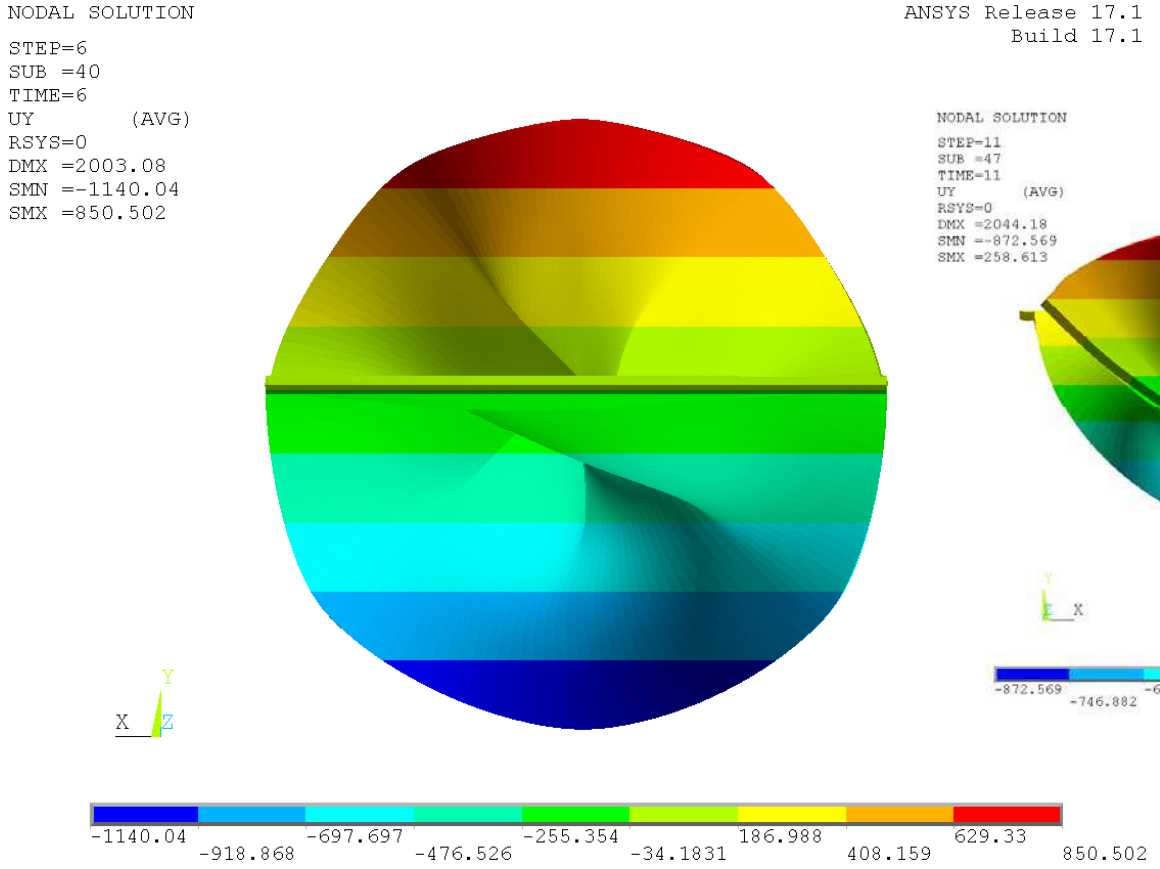
Stress in Belt

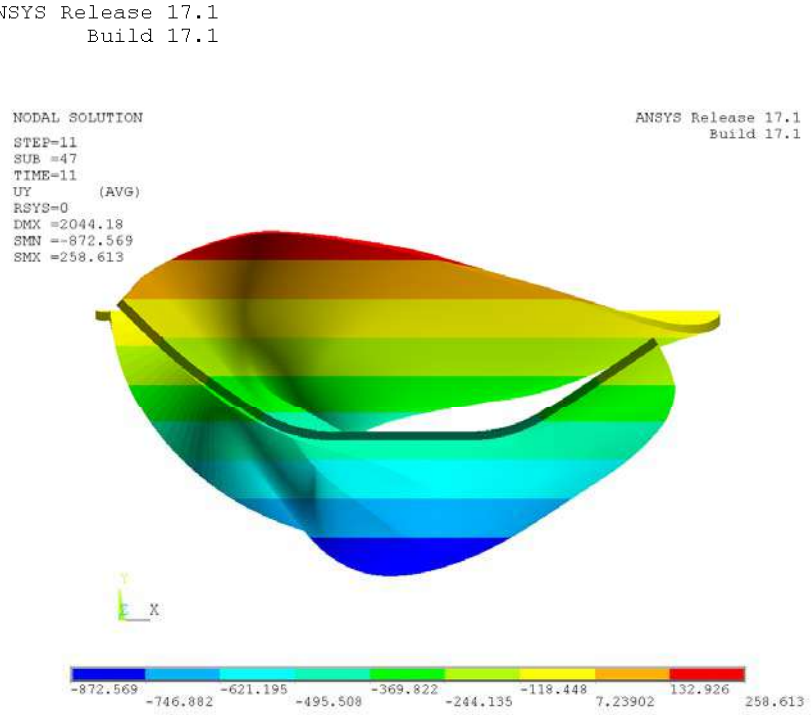




- Maximum belt edge stress is 190MPa (5.64 SF) in flat turnover.
- Belt edge stress is reduced by 16.7% in troughed turnover.
- Flat turnover is showing negative stress (deep blue) in the center; troughed turnover has positive center stress.

Comparison of Belt Profile





Troughed Turnover is 56.8% in height vs the flat turnover

Summary

- Troughed turnover can have lower belt edge stress (16%) and higher belt center stress, while the troughed turnover is 25% shorter.
- The troughed turnover needs smaller vertical space as well. The belt in troughed turnover is 56% in height compared to the flat turnover.
- This troughed turnover is accomplished by using multiple trough roll sets as guide rolls, with minimal finger rolls, so that belt cover wear is minimized.
- The guide rolls require almost no adjustment during the operation. The belt is in troughed shape at one end of the turnover and in flat shape at the other end. This simplifies idler and pulley arrangements.
- This numerical tool based on finite element analysis can also be used to analyze and improve other troughed turnover designs.

Any Questions?