Influence of Deformation of Compliant Rollers on Tape Steering during Automated Tape Placement

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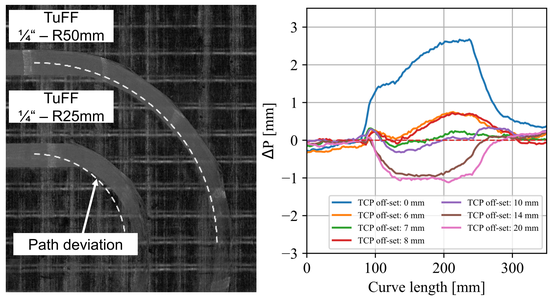
Motivation & Introduction

Previous steering experiment showed:

+ 10x reduction in minimal steering radii
▪ Shear strain on the outside edges
— Unusual high path deviation



Hypothesis & Approach

The path deviation is a combination of rigid transformation and rubber deformation while steering.

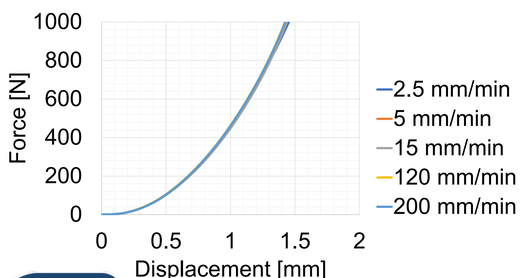
To investigate that the compliant roller will be modeled and validated

- Geometry validation using full 3D scan & regular caliper measurements.
- Element size convergent study on quarter size roller model (Static compaction)
- Full steering model Quasi-static

Validation experiments:

Load-Deflection

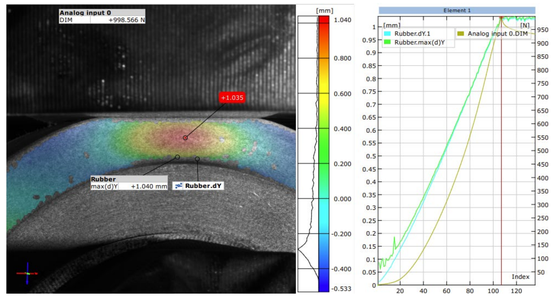
Roller was tested up to 1kN and side wall DIC was performed to capture deformation.



Digital Image Correlation (DIC)

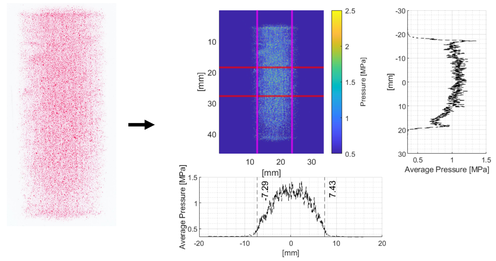
DIC gives full field in sighed in deformations:

- More data points to correlate to the model
- Possibility to estimate influence of friction



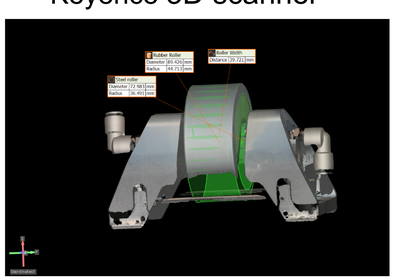
Pressure film

FUJIFILM Prescale super low pressure (LLW) [0.5-2.5 MPa] was used utilizing a high-resolution scanner (3200dpi).



Geometry confirmation

- Calipers
- Keyence 3D scanner



Element Name	Item Name	Value	
Rubber Roller	Diameter	89.426	mm
Rubber Roller	Radius	44.713	mm
Steel roller	Diameter	72.983	mm
Steel roller	Radius	36.491	mm
Roller Width	Distance	39.721	mm

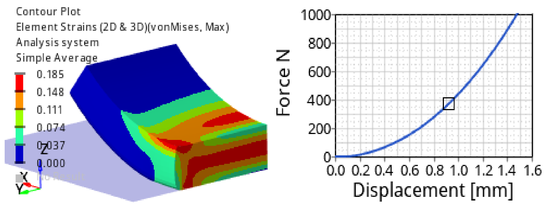
Feature	Nominal	Mean	SD
Roller Radius	45 mm	44.74 mm	0.056 mm
Rubber Thickness	8 mm	8.21 mm	0.264 mm
Edge fillet	-	1.62 mm	-

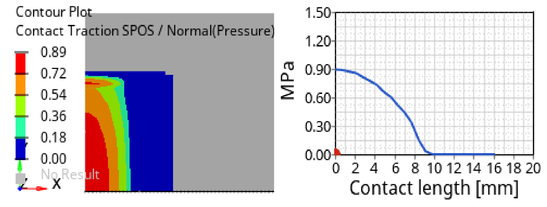
Simulations

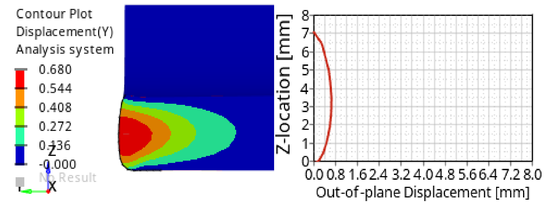
Quarter Model (convergence study)

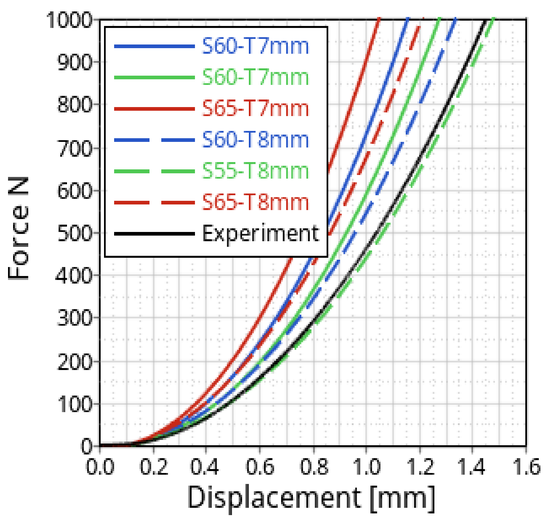
- Convergence study
- Load deflection
- Pressure distribution

Goof agreement with load deflection and DIC data.



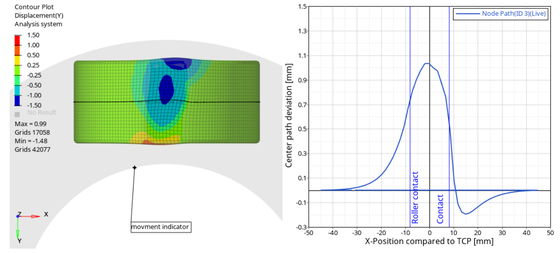






Full steering model

- 2 step non-linear steady state model
- Prediction of roller deformation matches the magnitude of the path deviation observed in the steering experiments



Summary & Conclusion

Previous experiments showed that the compliant roller has a huge influence while steering small radii using AFP. In order to predict what impact geometry, material, friction and the steering path have, the compliant roller of the Mikrosam AFP system was modeled using HyperWorks.

The simulations show good agreement with the experiments conducted. At steering radii < 100mm the compliant roller accounts for ~1mm of the measured path deviation were the nip point difference accounts for ~0.5mm. In future work this can be used to study the trade of different harnesses and thicknesses to minimize path deviation.

Acknowledgements

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