WINNING ON DURABILITY

Endurica User SPOTLIGHT

UNIVERSITY OF CALGARY

In their final year of studies at the University of Calgary Schulich School of Engineering, all students pursuing their bachelor's degrees complete an immersive team assignment known as the capstone design project. These projects enable students to put all they have learned into practice while engaging with the professional engineering community to solve challenges faced by industry.

A six-student team entitled their project High Inertia Impact Damping Tire for In-Wheel Hub Motors and set out to develop a tire that is durable, puncture-proof and adaptable for various environments. The tire is to be used in small vehicles compatible with the sponsor's proprietary in-wheel hub motor. Using Endurica's workflows, the students simulated the life expectancy of their 3D printed pneumatic tire designs with realistic material behavior and with realistic load cases. They also met *all* design requirements of the sponsor on time and on budget.

The theory behind rubber durability was the hardest part — there's so much more to it than metal durability. Actually using the software was easy because the manual was straightforward, very clear, and easy to use.

— Jared Schellenberg
Capstone Project Hardware Lead, B.S.M.E.
University of Calgary

Without the software the students would have achieved something but not to the extent and to the level that they actually did achieve. It was clear at their final presentation that the software gave them a strong tool to do their work and they actually gained a lot of knowledge.

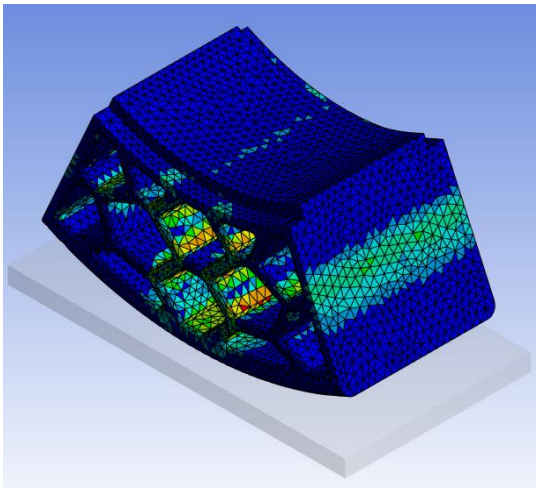
— Alejandro (Alex) Ramirez-Serrano
Professor, P. Eng.
Department of Mechanical Engineering
University of Calgary

Endurica Value Add for Calgary University Students:

- Empower engineering students with advanced tools
- Real world experience with Ansys and Endurica
- Get Durability Right on short timeline and student budget
- Completion of multi-objective, high-performance design project

Endurica CL™
Fatigue Analysis Software

Ansys



See the Capstone Project Poster on reverse

Endurica LLC | 1219 West Main Cross St., Suite 201 Findlay, Ohio 45840 USA | +1.419.957.0543 | endurica.com

Endurica
Get Durability Right®

High Inertia Impact Damping Tire For In-Wheel Hub Motors

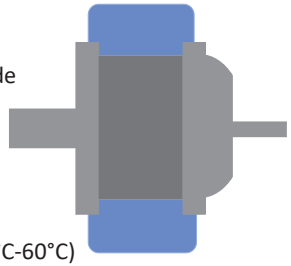
Allan Will, Bilal Abdelhadi, Colton Cuthill, Hamad Rizwan, Jared Schellenberg, Ronel Del Rosario

SCHULICH School of Engineering — UNIVERSITY OF CALGARY

UNIVERSITY OF CALGARY

Introduction

The purpose of this project is to develop a tire for a specific in-wheel hub motor used in small 4-wheeled vehicles.



Our tires focus on durability and adaptability, allowing use in a wide variety of applications.

Design must:

- Withstand drop 80-100 inches
- Be easy to install
- Be Temperature resistant (-45°C-60°C)
- Have a lifetime >10 years

Problems

- Vehicles such as rovers are deployed in hazardous conditions and complex terrain
- Wheels are the weakest link as they are susceptible to punctures
- Wheels need to be constantly repaired or replaced
- Presents the need for tires that are durable and maintenance free

Concept Selection

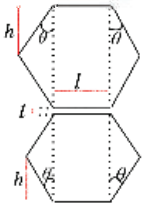
Category	Category Weight	Non-Pneumatic Tire	Shock Tire	Foam Filled Tire	Pneumatic Tire
Rigidity	0.7	4	2	1	3
Impact damping	1.0	3	4	2	1
Traction	0.4	4	1	3	2
Load Capacity	0.8	4	3	1	2
Puncture/Damage Resistance	1.0	4	2	3	1
Mass	0.6	3	1	2	4
Cost	0.6	2	1	3	4
Manufacturing	0.6	2	1	3	4
Weighted Average	-	2.35	1.50	1.56	1.71

Weight scale 1.0 – Most important

Ranking: High (4) – Best ⟶ Low (1) – Worst

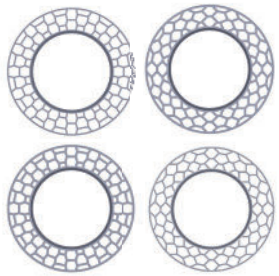
Geometric Analysis

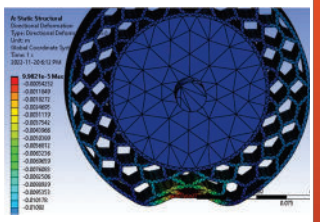
- 4 Potential NPT designs were considered
- Honeycomb design found to be highest performer
- Different variations of honeycomb design were researched



Design	Structural Compliance Test		Uneven-Surface Test		Shear Resistance Test			Torque Test	
Load	250N	450N	250N	450N	100N	200N	300N	32 N*m	70 N*m
B Deform (mm)	2.9	5.36	10.8	19.5	6.6	13.3	19.9	4.1	9
B Stress (MPa)	0.65	1.17	1.59	2.86	0.75	1.5	2.25	0.79	1.73

- Honeycomb designs of various dimensions underwent 4 structural tests in Ansys.
- "Design B" determined to be the best after producing the results shown in the table.





Material Selection

3D Printing

Faster, cheaper production for single sets of tires

PLA
Standard 3D Printing Material
Too soft, must be stiffer

TPU

95A
Too stiff, doesn't allow for slight deformations under load.

90A
Tensile Strength : 30 MPa
Young's Modulus: 6.17 MPa

Casting

Cheaper production for many sets of tires, on an industrial scale

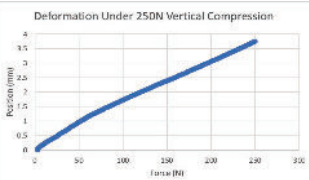
- 90A Poly U is best option for this design

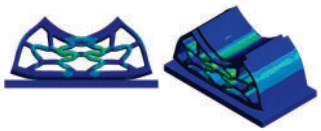
Final Test Results

- Test coupon was designed to accurately replicate properties of full-sized tire, was then 3D printed from 90A TPU

- Long-term fatigue analysis was done in Endurica, and physical fatigue test cycled between 250N and 0N every 2.5s for 100,000 cycles.
- Endurica predicts a nominal lifetime of over 100 million cycles

Test	Max Force Tested N	Displacement @ Max Force (mm)	Failure? (Y/N)
Normal Compression	250	3.755	N
Uneven Compression	250	5.237	N
Punctured Compression	350	5.596	N





Conclusion

- Final Design meets requirements outlined by sponsor:

Temperature Resistant

Impact Resistant

Puncture Proof

Light Weight

- Under 4mm of deformation under 250 N load meets rigidity requirements
- Tire can be easily attached to hub with single Allen-key

Possible Improvements:

- Optimize Geometry
- Shear / Rolling resistance tests
- Determine Appropriate Tread Pattern
- Scalability Optimization