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Radial Honeycomb Lattices Using Corrugating Gears

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Introduction

Honeycomb lattices, shown in Fig. 1, absorb a large amount of energy when crushed, as shown in Fig. 2. This would be very useful in satisfying regulatory requirements for radioactive materials packages. Current techniques for manufacturing cylindrical honeycomb are slow and don't scale well to mass production.

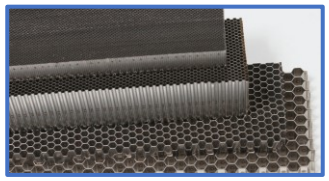

Figure 1: Honeycomb lattices [1]

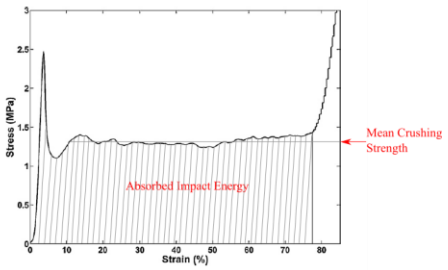

Figure 2: Example stress-strain curve of crushed honeycomb lattice (modified from [2].

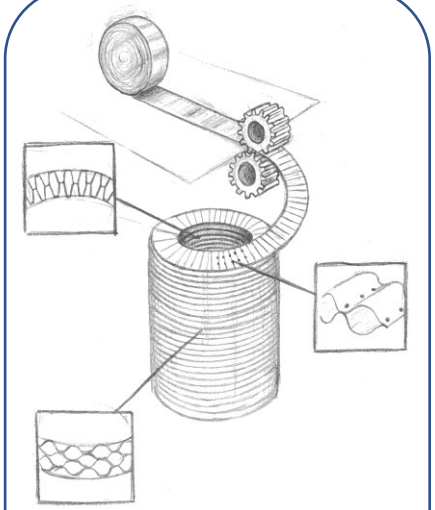

Figure 3: Conceptual sketch of the new cylindrical honeycomb manufacturing method.

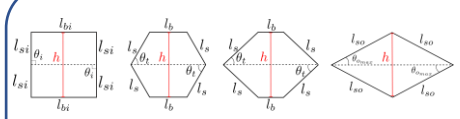

Figure 4: Possible radial honeycomb cross-sectional profiles.

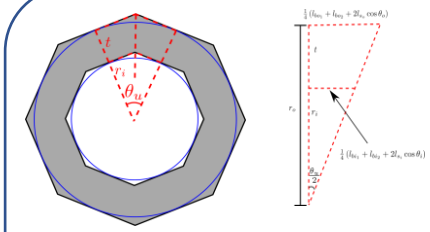

Figure 5: Honeycomb cylinder top view (left) showing geometric relationships (right) used to derive thickness limit..

Methods

A radial honeycomb lattice, shown in Fig. 3, using geometrically derived relationships as shown in Figs. 4 and 5, can be fully designed, including corrugating gears for manufacturing, using the process flow described in Fig. 6. The corrugating gear design is shown in Fig. 7 with an example in Fig. 8.

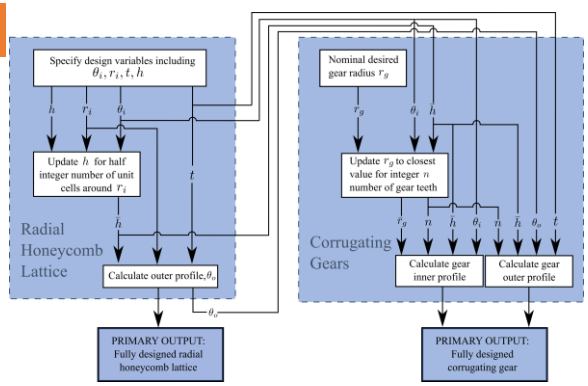

Figure 6: Process flow for determining desired cylindrical honeycomb and corrugating gear shapes.

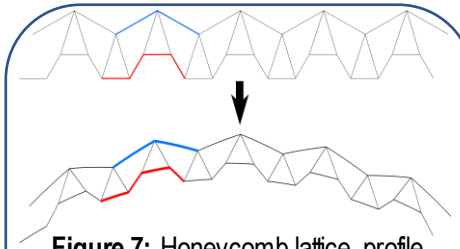

Figure 7: Honeycomb lattice profile wrapping for gear design using the relationships:

$$L_s = \int_0^{\theta_2} \sqrt{r(\theta)^2 + \frac{dr}{d\theta}^2}\, d\theta$$

$$r(\theta) = \frac{r_o - r_i}{\theta_2}\theta + r_i$$

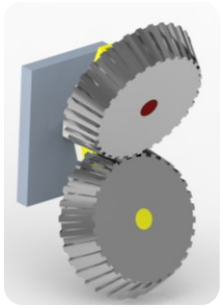

Figure 8: CAD model of corrugating gears.

Conclusion

The honeycomb manufacturing process described here allows for rapid bulk manufacture of cylindrical honeycomb, an industry first.

Acknowledgements:
Special thanks to Kurt Eberl, Thomas Heusel, and Hillary Beauliere.

References
[1] www.indyhoneycomb.com
[2] M.K. Khan, T. Baig, and S. Mirza "Experimental investigation of in-plane and out-of-plane crushing of aluminum honeycomb" *Materials Science and Engineering A* 539 (2012)
[3] K.R. Eberl, J.P. Flach, J.M. Shuler, P.S. Blanton, and W.R. Johnson "Radially oriented honeycomb and structures formed therefrom" USPTO App. No. 17/831,166