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Experimental Comparative Analysis of Cycloidal and Planetary Gearboxes for Compact Actuator Applications

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INTRODUCTION

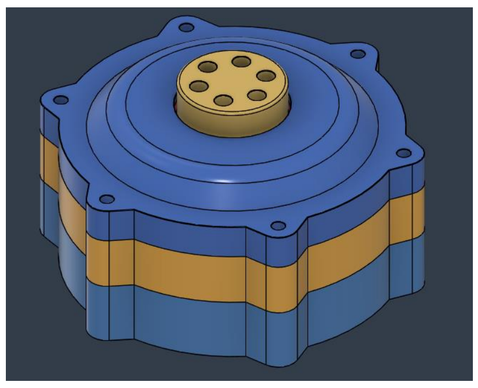
Robotic actuators require compact, efficient, and low-backlash transmission systems. This project investigates the performance differences between cycloidal and planetary gearboxes through the design, manufacture, and experimental testing of prototype systems under identical conditions.

OBJECTIVES

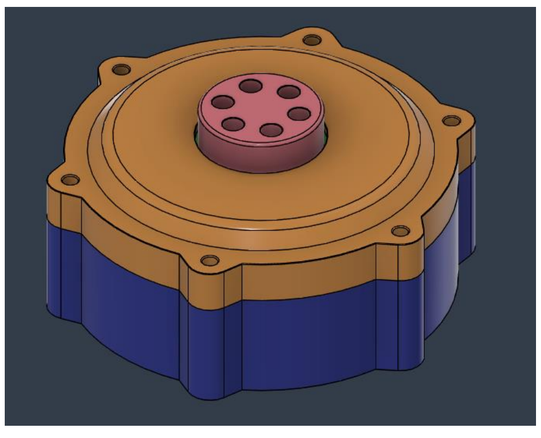
- Design comparable ~20:1 reduction gearboxes
- Manufacture functional prototypes
- Develop a common test rig
- Compare: Efficiency Backlash, Torsional stiffness and Performance vs speed

DESIGN & MANUFACTURE

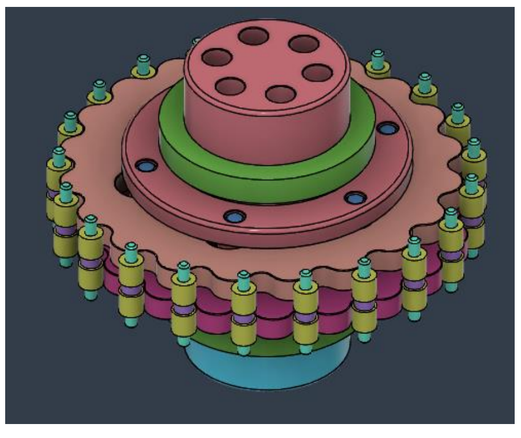
- Dual-stage planetary gearbox
- Dual-disc cycloidal gearbox
- Resin internal components
- PLA housing structures
- Metal bearings/bushings used for wear resistance



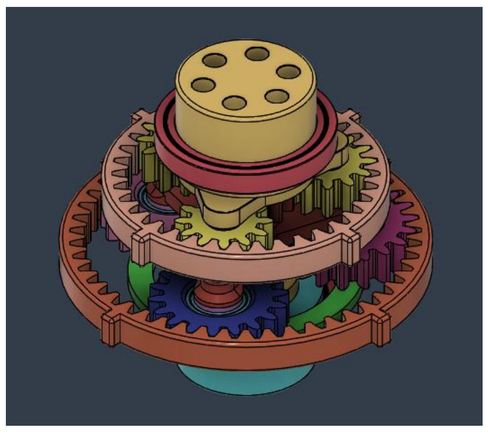
Final iteration of planetary gearbox with colour coded components



Final iteration of cycloidal gearbox with colour coded components



Final iteration of internal cycloidal gearbox mechanism with colour coded components

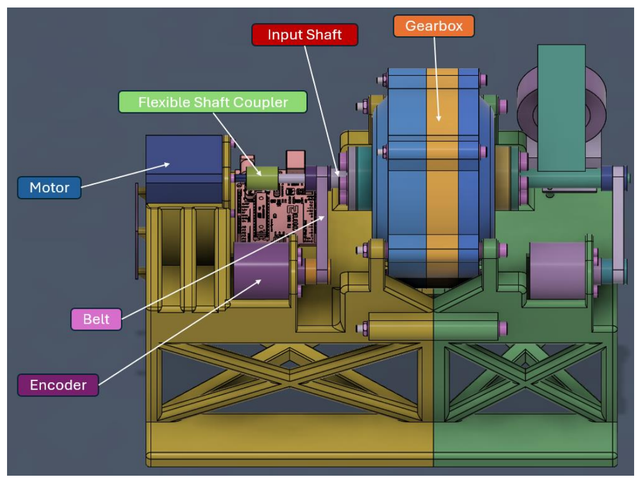


Final iteration of internal planetary gearbox mechanism with colour coded components

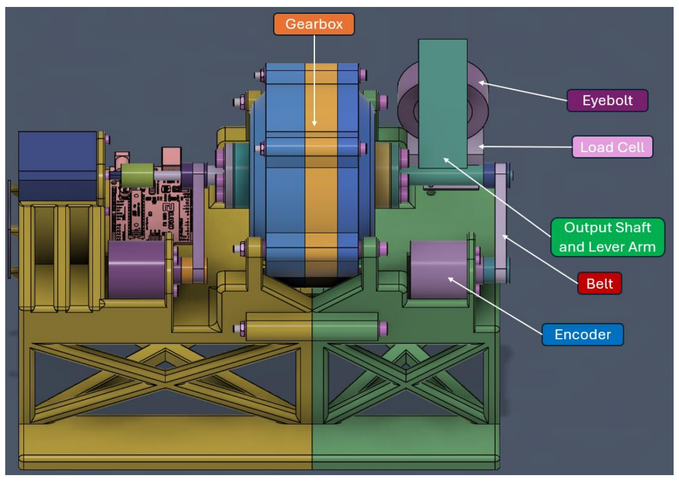
TEST RIG & METHODOLOGY

A common experimental rig was developed to ensure fair testing conditions between gearbox types. Input and output speeds were measured using rotary encoders while output torque was calculated using a calibrated load cell and 100 mm lever arm.

Design → Manufacture → Testing → Data Processing → Results

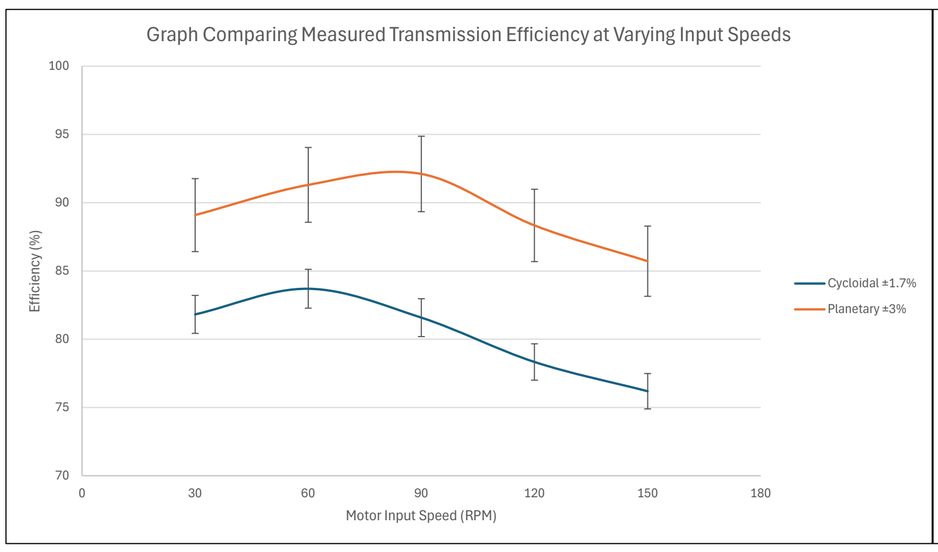


Input shaft side of test rig, highlighting key components

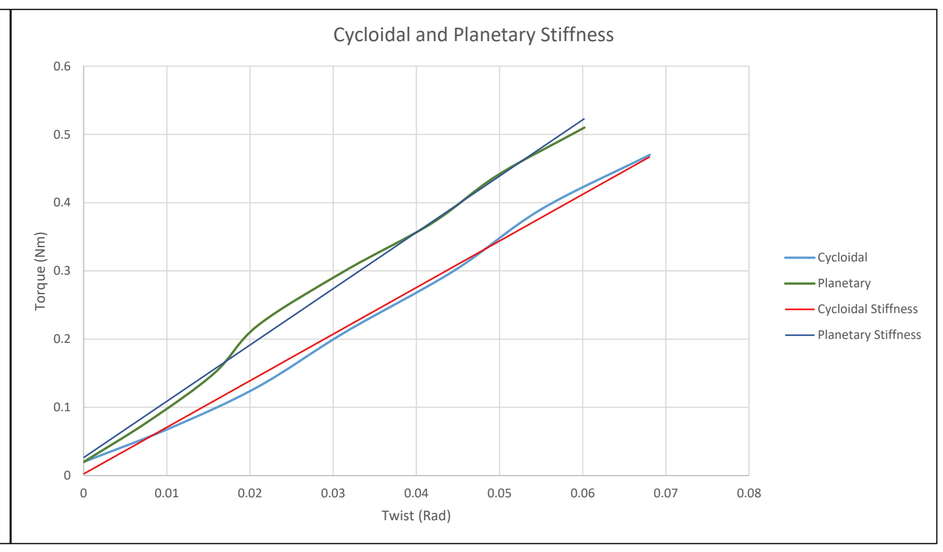


Output shaft side of test rig, highlighting key components

RESULTS



Graph comparing measured transmission Efficiency at Varying Input Speeds



Graph showcasing torque-twist relationship in the planetary and cycloidal gearboxes

Measured backlash for planetary and cycloidal gearboxes

Gearbox Type	Total Backlash Input (°)	Total Backlash Output (°)
Planetary	4.20	0.21
Cycloidal	2.25	0.1125

Conclusion

The planetary gearbox demonstrated superior efficiency and torsional stiffness, while the cycloidal gearbox achieved lower backlash. The project successfully demonstrated how gearbox topology significantly influences actuator performance characteristics under identical testing conditions.

Summary of findings

Metric	Planetary	Cycloidal
Peak Efficiency	~92%	~84%
Torsional Stiffness	8.25 Nm/rad	6.83 Nm/rad
Output Backlash	0.21°	0.1125°