Reducing Friction, Reducing Footprint: Accelerating Sustainable Manufacturing through Scalable High-Throughput Testing of Water-Based Lubricants

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PROJECT OVERVIEW

Friction and wear are a hidden cost of manufacturing: **~30%** of a car's fuel energy is lost to friction; wear costs industry hundreds of **billions of pounds** a year.

Figure 1: Relevant UN SDGs addressed.

Water-based lubricants are more sustainable than oil-based lubricants. However, are they really fit for industry application?

This project utilised Imperial's UltraMAN robotic system to evaluate the performance of water-based lubricants under high-throughput manufacturing conditions.

OBJECTIVES

- Automate multi-cycle coefficient of friction (COF) testing of water-based lubricants
- Characterise COF & galling vs. temperature and sliding distance
- Compare and evaluate performance of different lubricants

METHODS

- UR10 robot arm (±0.1 mm, ±0.1 N accuracy)
- Strip feeder → 2mm/cycle, unlike pin-on-disc tests
- Heater → up to 550°C with PID control
- Force/torque data logged at 125Hz per stroke

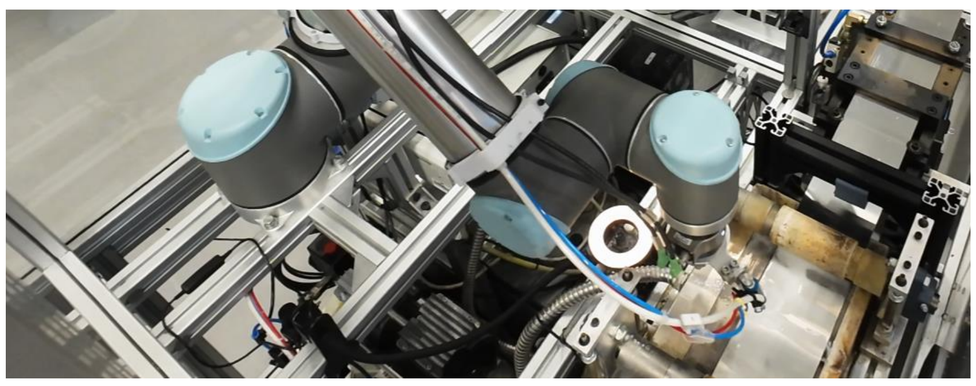

Figure 2: Internal view of UltraMAN.

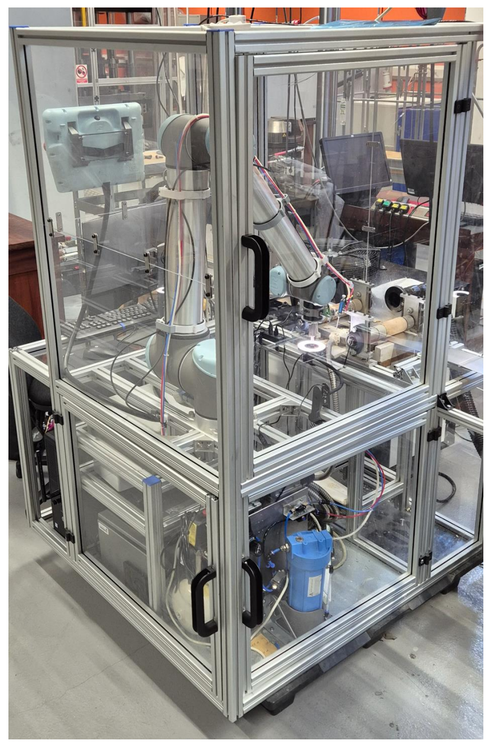

Figure 3: External view of UltraMAN.

RESULTS

COF is measured across a 300–350°C temperature range for three water-based lubricants: F27AL, F420N and L-CACP799. It is subsequently averaged over sliding distance and cycle number.

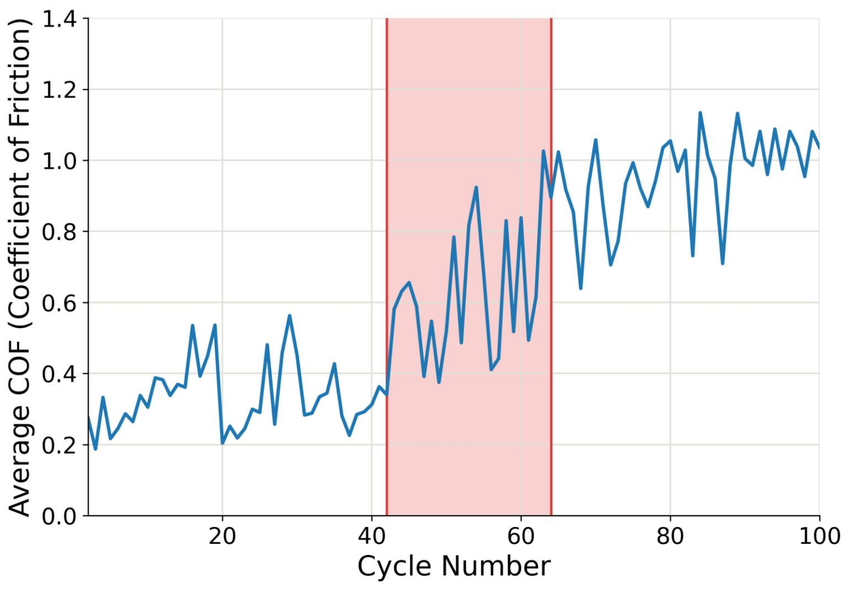

Figure 4: Average COF against cycle number of a sample dry sliding test at 170°C. Rapid increase in COF between cycle 42-64 is due to galling (see *Fig. 6*).

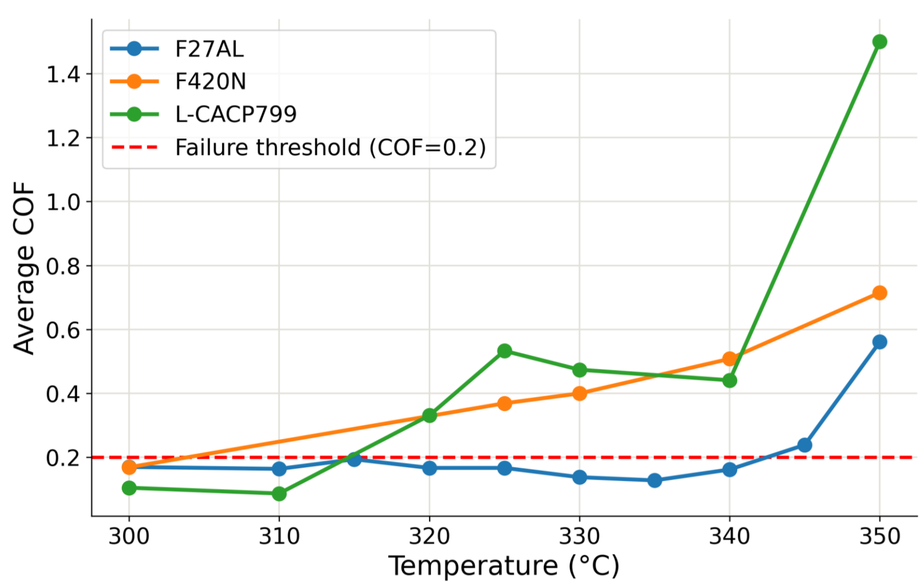

Figure 5: Average COF against temperature of the three water-based lubricants, for performance comparison.

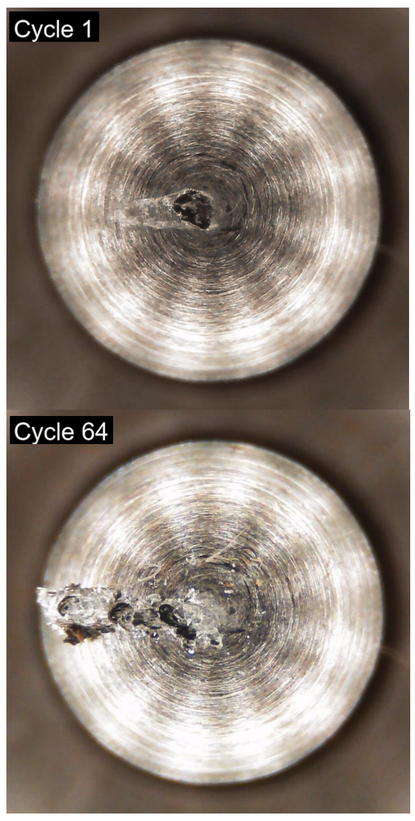

Figure 6: Build-up of transferred aluminium on metal pinhead – "galling".

CONCLUSION

- Lubricant failure temperatures at around 345°C (F27AL), 310°C (F420N), and 320°C (L-CACP799).
- F27AL is most stable for high temperature, high-throughput manufacturing conditions.
- L-CACP799 is least desirable, due to sudden COF spike.

IMPACT & DISSEMINATION

Collaboration with Geely Auto Group – tutored a 6-day STEM camp for gifted 13-18 young talents at ZEEKR's Intelligent Factory, teaching tribology and robotics built on the UltraMAN research.

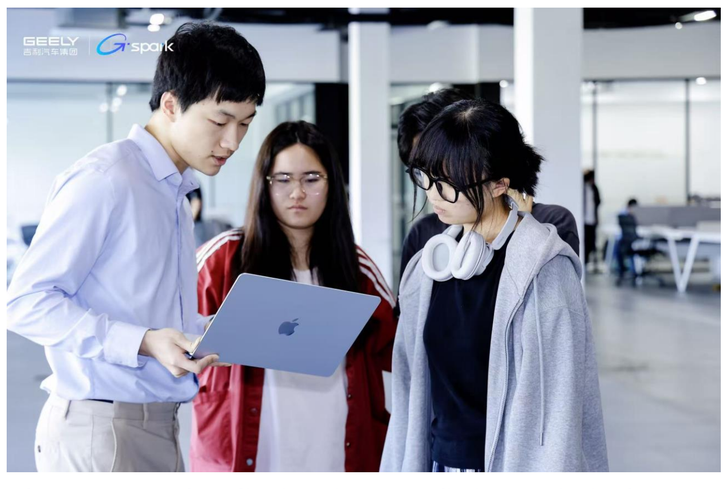

Figure 7: Mentoring gifted students on tribology and robotics.

Figure 8: Group photo of the youth camp.

ACKNOWLEDGEMENTS

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