Leaf Fall, Chemistry and Effects on Friction

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Background

This project aims to answer the following questions;

- What effect does chemistry of different leaf species have on the reduction in friction between wheel and rail?
- When do leaves fall and how will this impact rail network performance?
- How do the leaves reach the wheel-rail interface?

Leaf contamination in the rail-wheel interface is a seemingly seasonal issue, since nearly all deciduous trees lose their leaves in the autumn/wintertime of the year. This is especially important seeing as a mature tree can lose between 10,000 and 50,000 leaves a year [1].

The coating generated by leaf matter being squashed onto the track by the wheels causes the trains to slide when braking or accelerating. Even small amounts of leaf material constitute large safety concerns and problems for train operators and those involved in the infrastructure maintenance, such as station overruns and signals passed at danger (SPADs) [2].

The industrial sponsor for this project is the Rail Safety and Standards Board (RSSB).

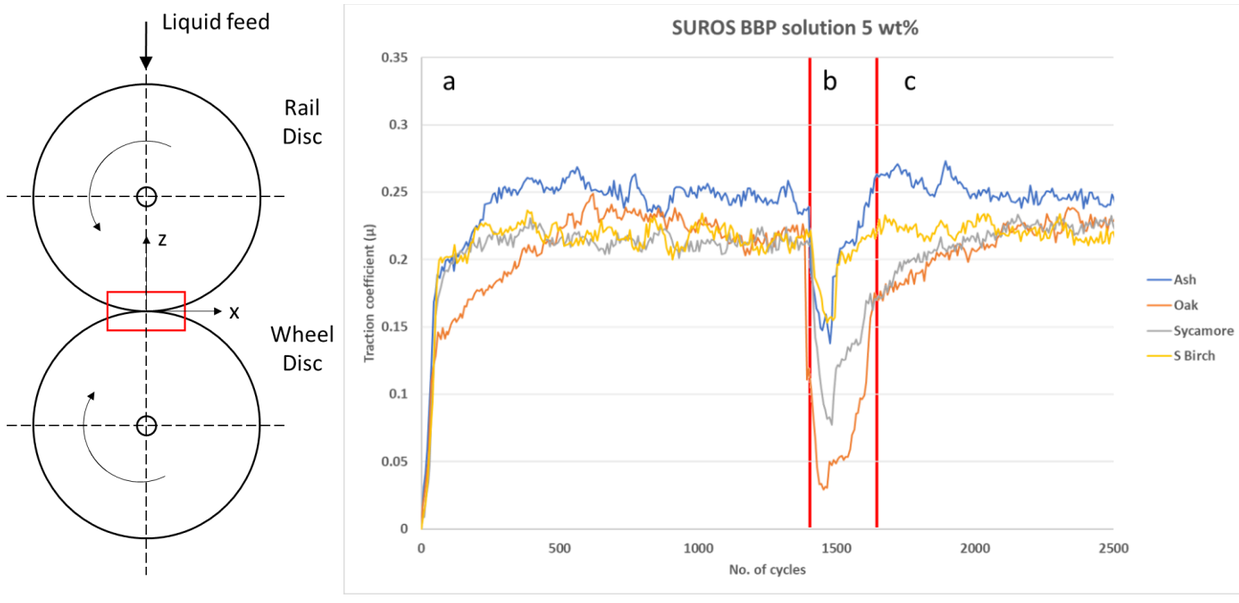
Four tree species have been chosen (based on advice from the Met office and KPI data from RSSB), to be analysed for this mini project. They are **Sycamore**, **Ash**, **English Oak** and **Silver Birch** and are all deciduous trees since they will lose their leaves in the autumn time of the year. The Sycamore results will be compared with the previous work [2] in order to provide validation.

Friction tests

The friction tests of leaf material involve the SUROS (Sheffield University ROlling Sliding) rig in the SUROS Laboratory which measures the coefficient of friction for rolling contact.

Black "Teflon like" leaf layer (left), Leaves near track (right)

The BBP would be dissolved in distilled water to return it to a solution, then injected into the twin disc contact of the SUROS rig.

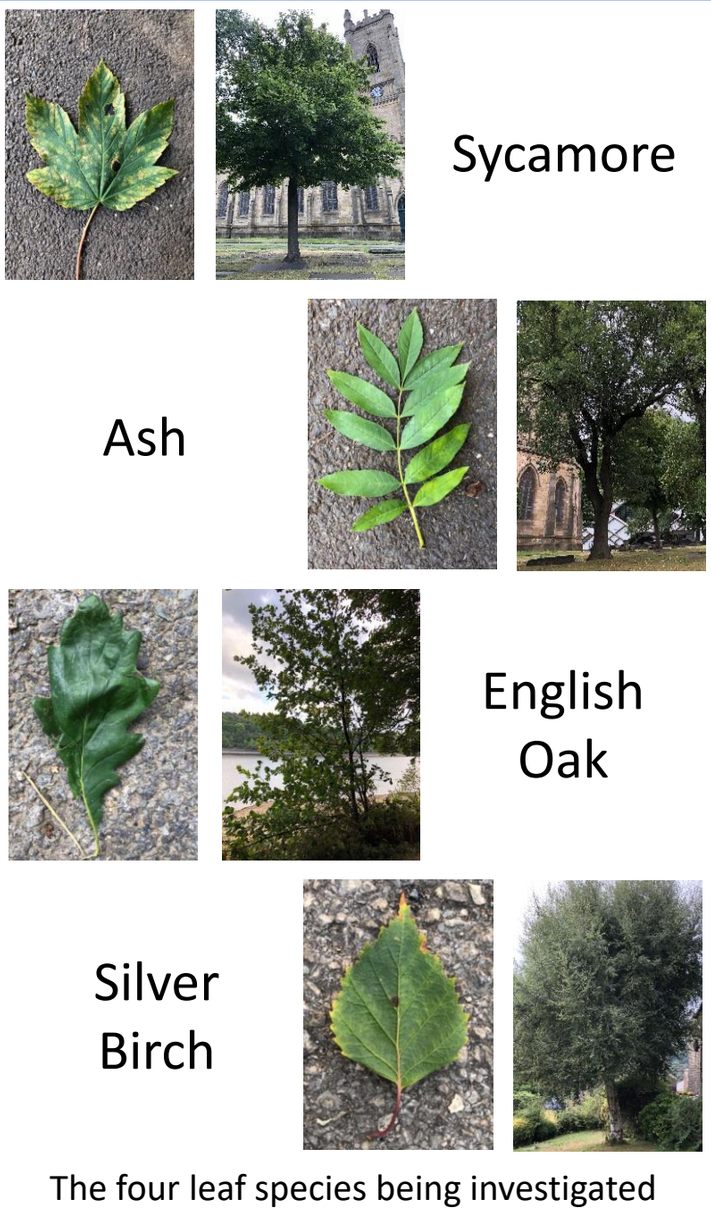


a – friction before leaf material is applied

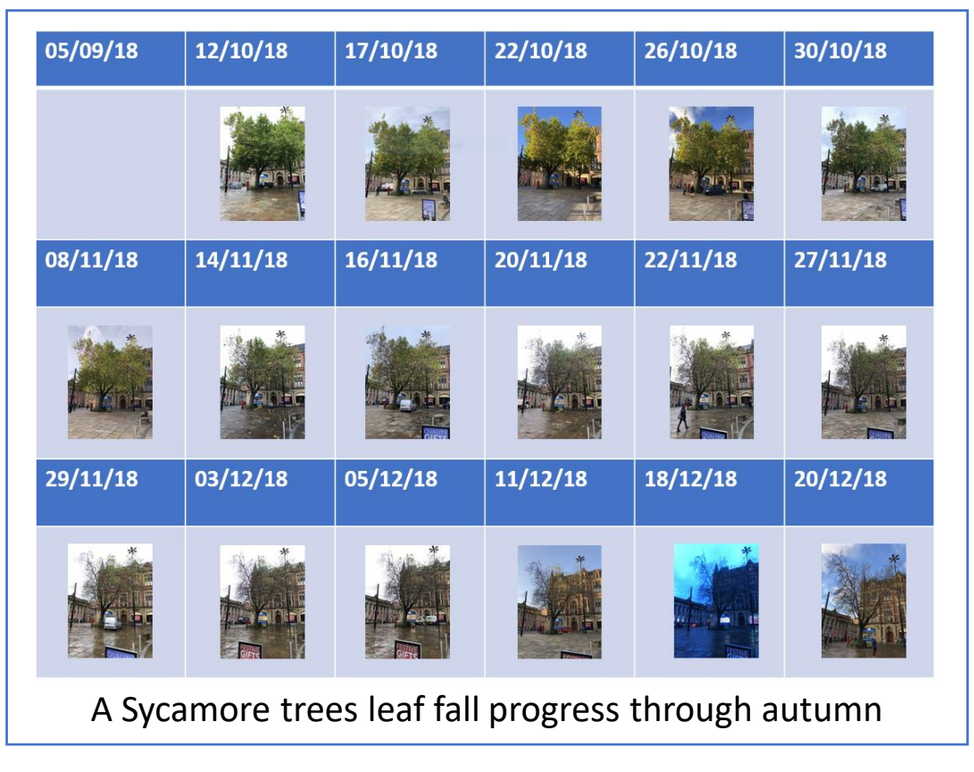
b – friction is at lowest level as BBP enters the contact

c – friction level returns as BBP is consumed

SUROS rolling sliding twin disc rig schematic (left), and recorded SUROS data (right)



The four leaf species being investigated



A Sycamore trees leaf fall progress through autumn

Leaf fall analysis

The leaf fall throughout the autumn-winter period was monitored by selecting specific trees/groups of trees and periodically photographing them from the same angle.

The images are then arranged into chronological order (see table to right) so that the leaf density and leaf fall can be tracked. This data will be recorded in parallel with weather data consisting of; ambient temperature, pressure and humidity as well as rail head temperature.

The images and weather data were captured along Sheffield's Supertram network. It will also be compared against low adhesion incident KPI reports from Supertram.

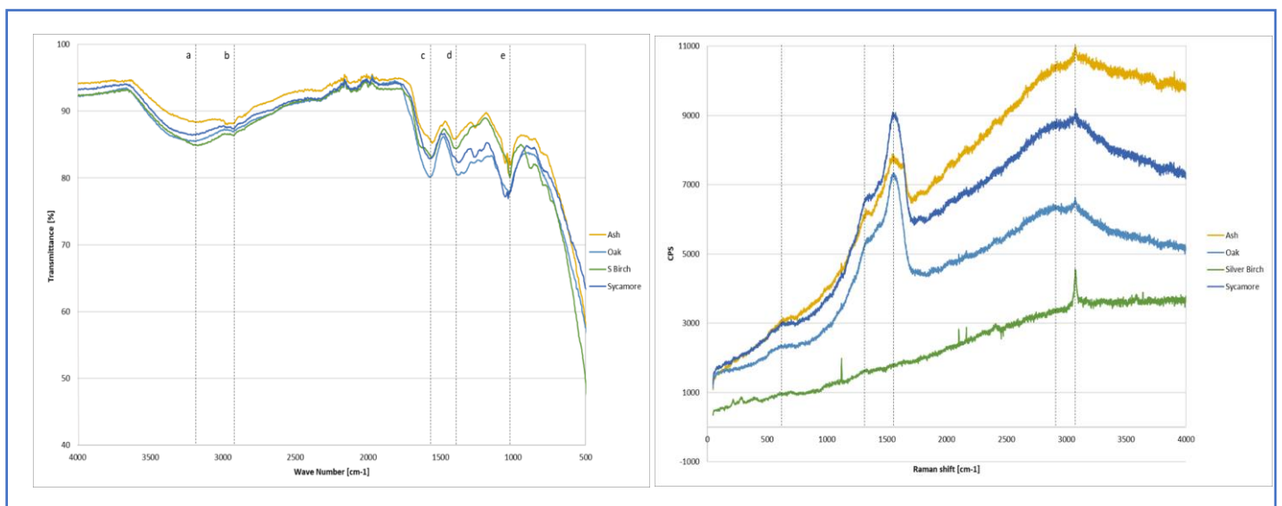
Leaf fall analysis is being done to classify leaf fall styles and impacts of cross winds on falling leaves and the relocation of leaves on the ground.

Chemical analysis

So far, chemical analysis via Fourier Transform-Infrared Spectroscopy (FT-IR), Laser Raman Spectroscopy (LRS) and X-ray Photoelectron Spectroscopy (XPS) has been carried out on rail steel samples reacted with the leaf types shown above.

All three methods generate a spectra of the reacted leaf samples, these results were then analysed and compared against each other.

The samples took the form of BBP (Brown leaf Black Precipitation) powder. BBP was generated by making a tea with blended brown leaves, then submerging a piece of rail steel in and allowing it to react. The solution is then boiled to evaporate any water, leaving behind the BBP.



FT-IR intensity spectra for Ash, Oak, Silver Birch and Sycamore BBP (left), Raman intensity spectra averaged for the four BBP samples (right)

References

[1] Robertson R. Detecting wheel flats and more – Rail Engineer n.d. https://www.railengineer.uk/2017/10/17/detecting-wheel-flats-and-more/ (accessed February 12, 2018).

[2] Ishizaka K. Confirmation Review final draft_1 Kei. Sheffield: 2017.

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