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Applicability of Mechanical Strength Tests for Biomass Pellet Characterisation

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Scope of Study

Aims: To explore how biomass pellet mechanical strength relates to milling behaviour

Objective: Determine durability, quasi-static and dynamic strength of biomass pellets and correlate results to milling energy in 3 different mills; Hardgrove Grindability Index (HGI), Ring-Roller, and Knife Mill

Wood Pellets

Sunflower Pellets

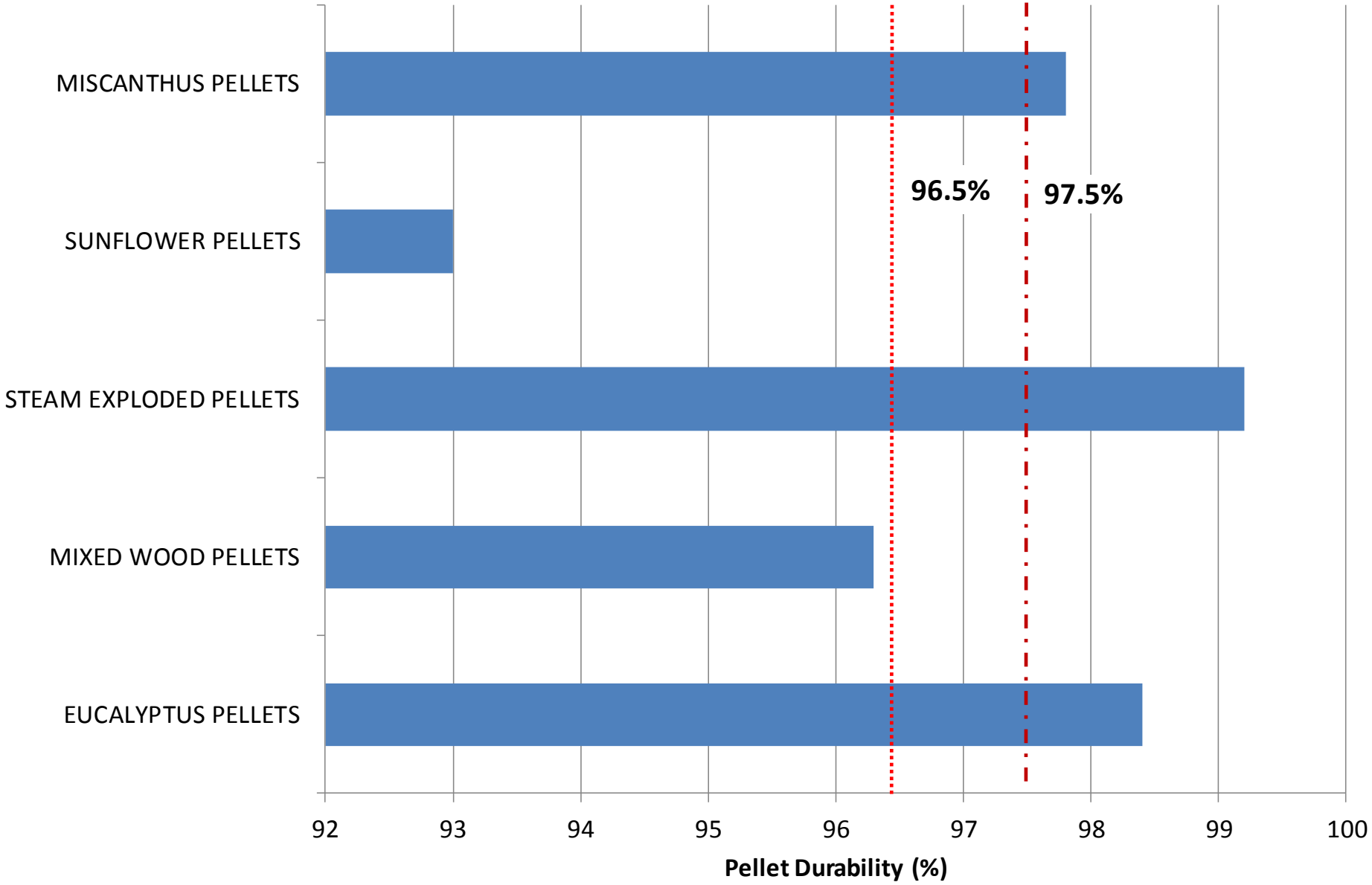
Eucalyptus Pellets

Miscanthus Pellets

Steam Exploded Pellets


Microwave Pellets

Pellet Durability Test



- Pellet durability tested in accordance with BS EN 15210-1:2009
- $D_u = \frac{m_A}{m_B} \times 100$
- Sunflower and mixed wood pellets failed to meet standards

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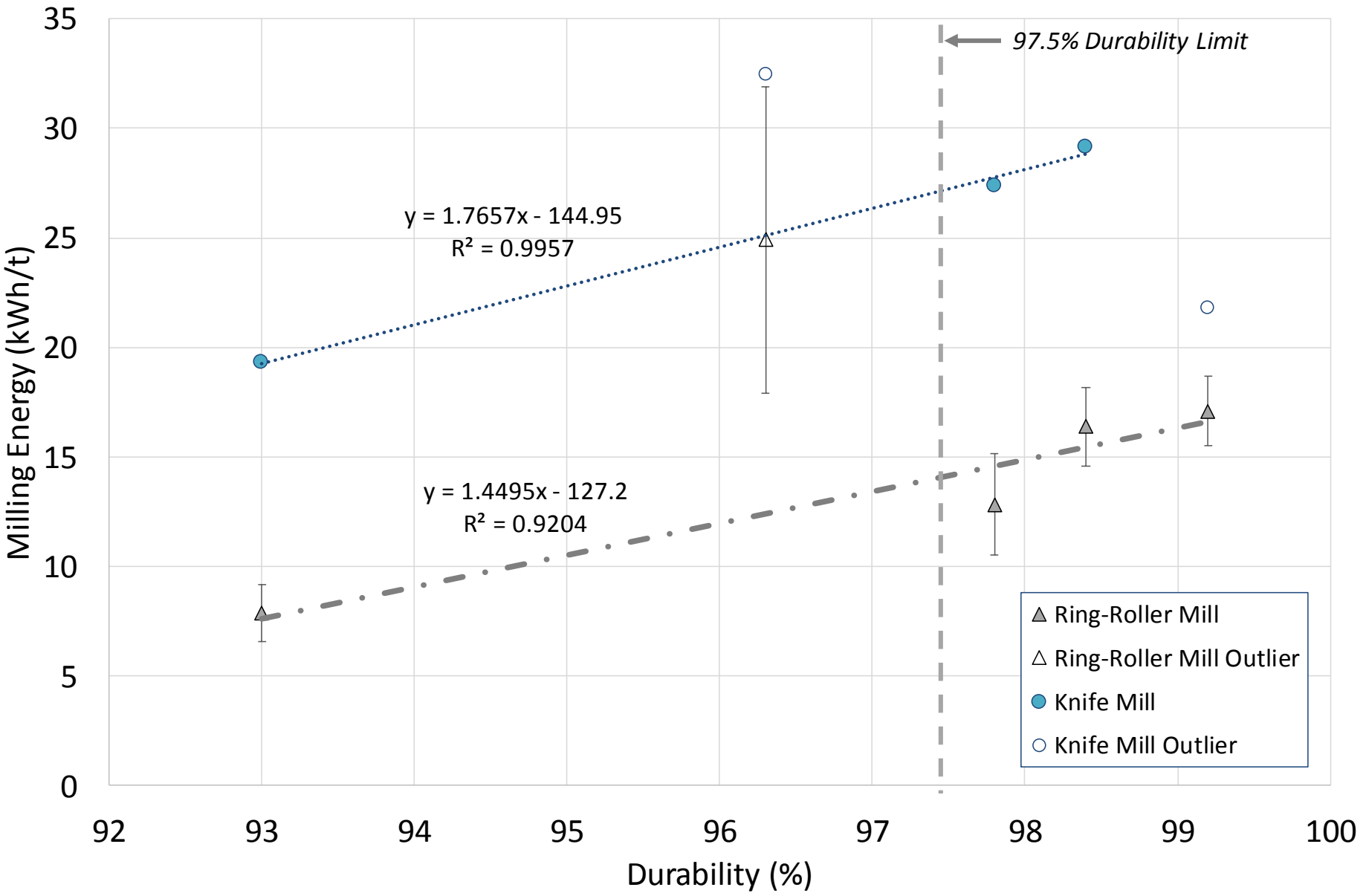
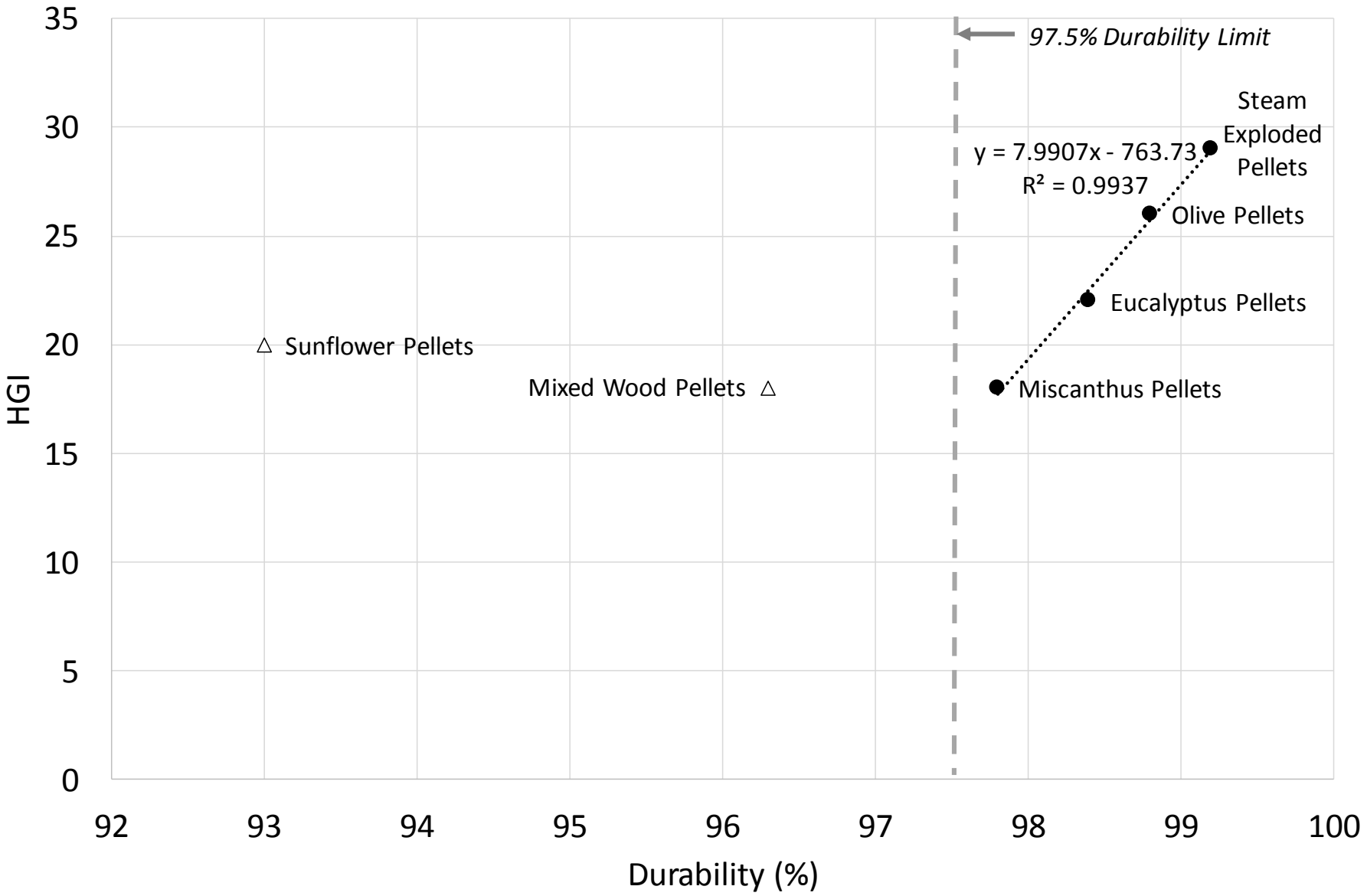
Correlation between Durability and Milling Energy

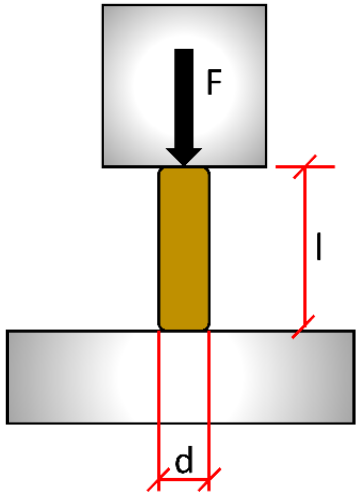


Correlation between HGI and Durability

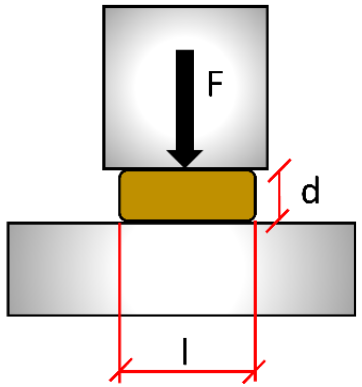


Quasi-Static Mechanical Tests

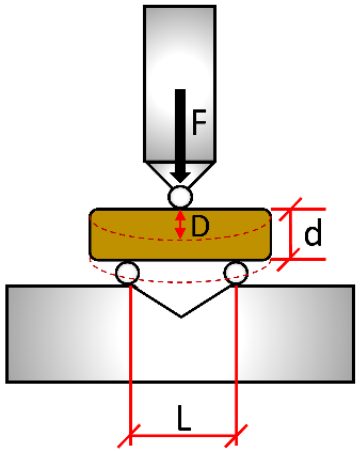
- Samples measured in 3 orientations axial, diametral and flexure using Instrom Mechanical Testing Machine
- Stress and strain values obtained from Force-Extension curves
- Test gives low strain rate (1 mm/min) mechanical strength for biomass pellets



a) Axial



b) Diametral



c) Flexure

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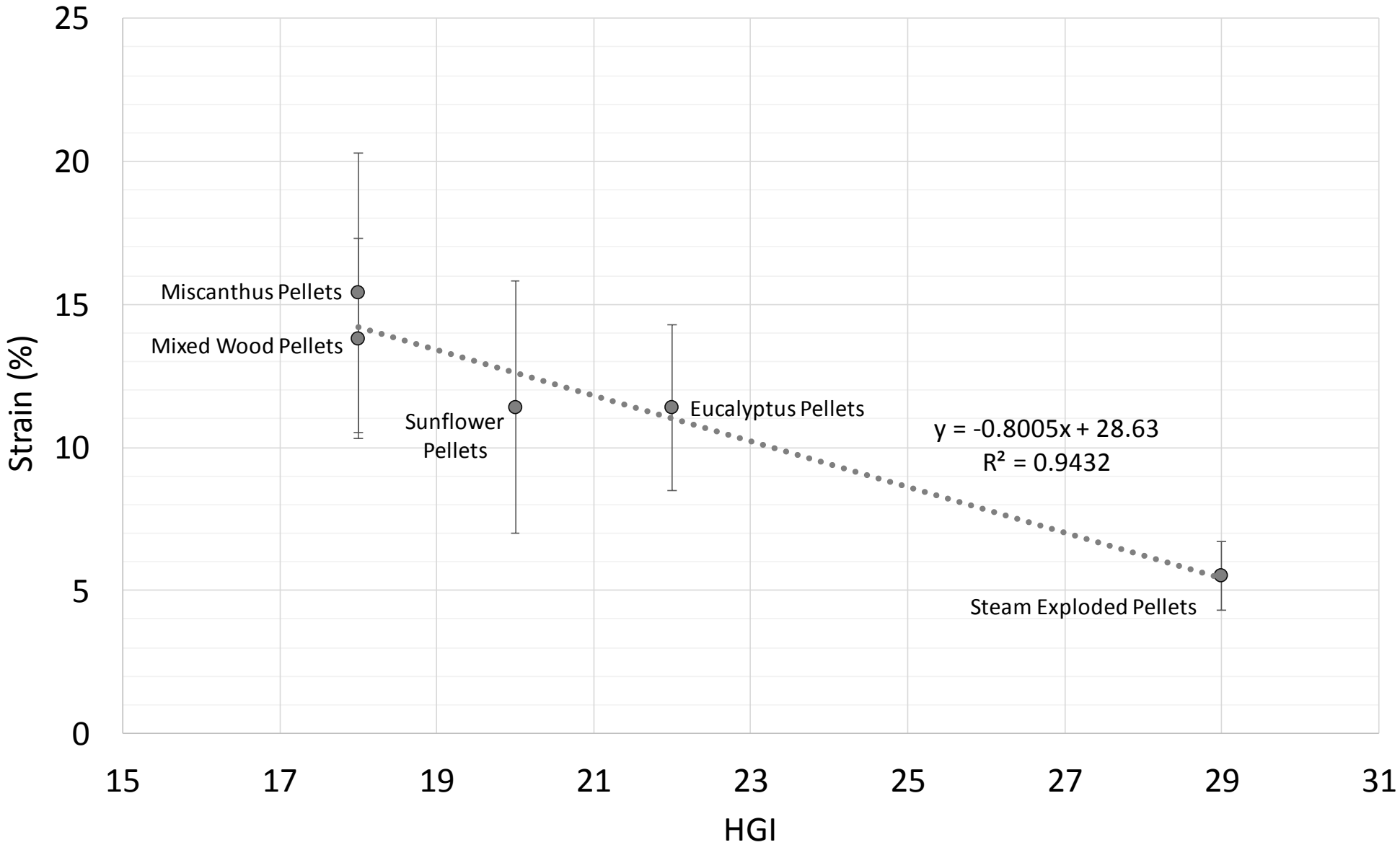
Correlation between Diametral Strain and HGI



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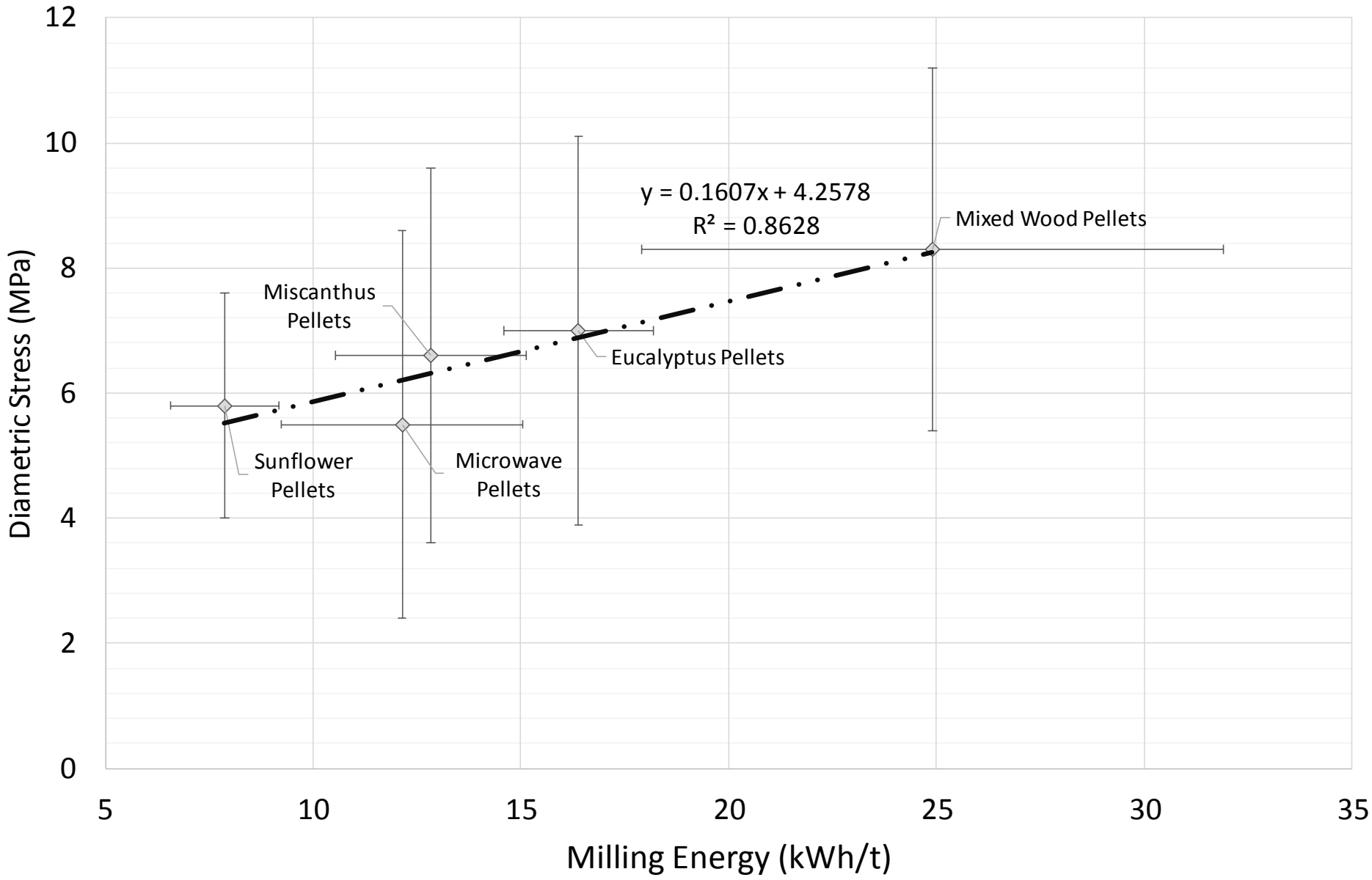
Correlation between Diametral Stress and Ring-Roller Mill Energy



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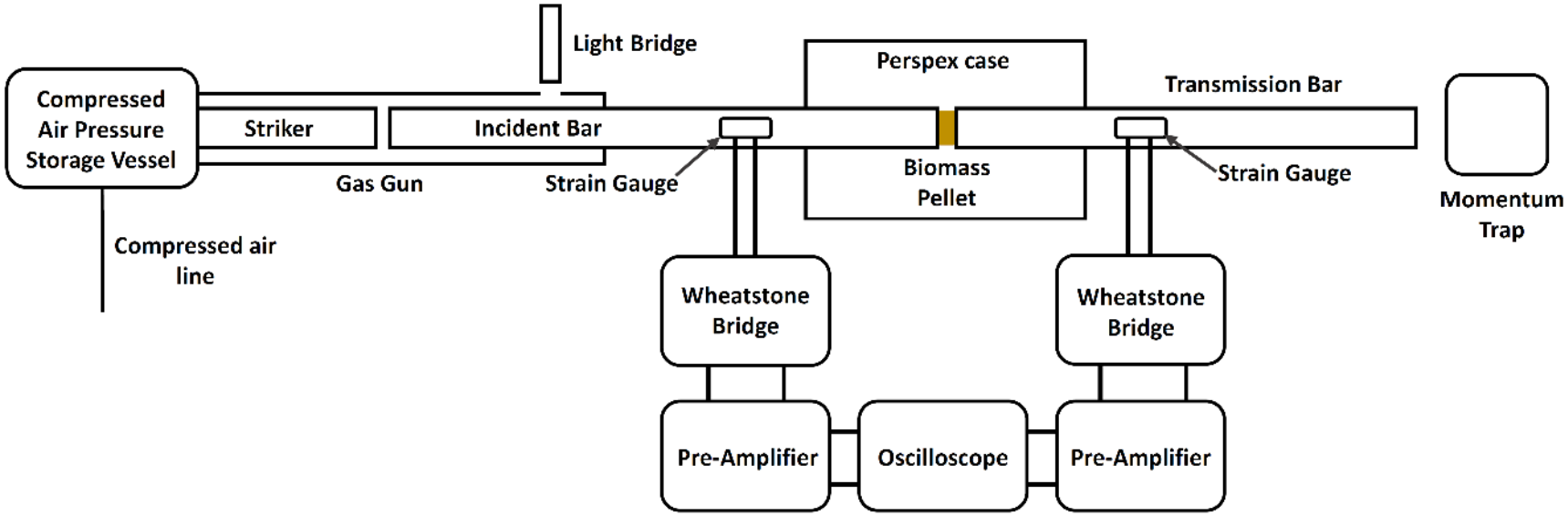
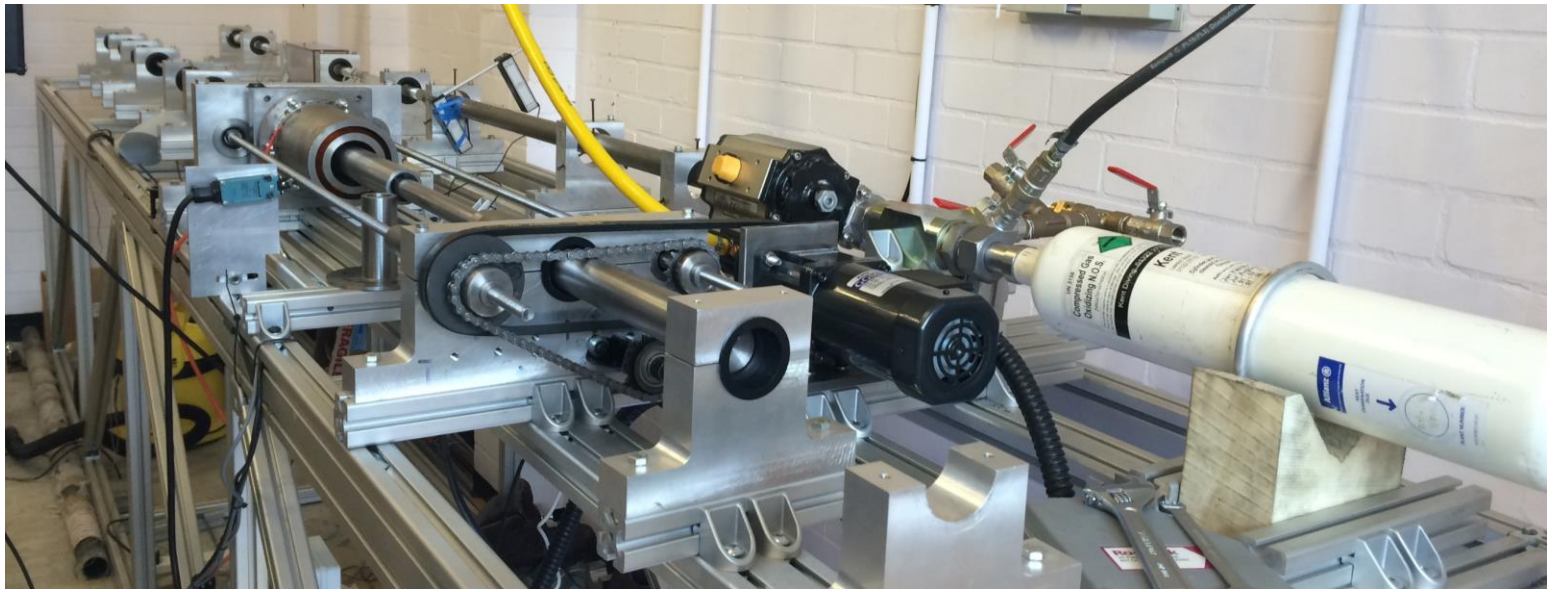
Dynamic Mechanical Tests – Split Hopkinson Pressure Bar





SHPB Test

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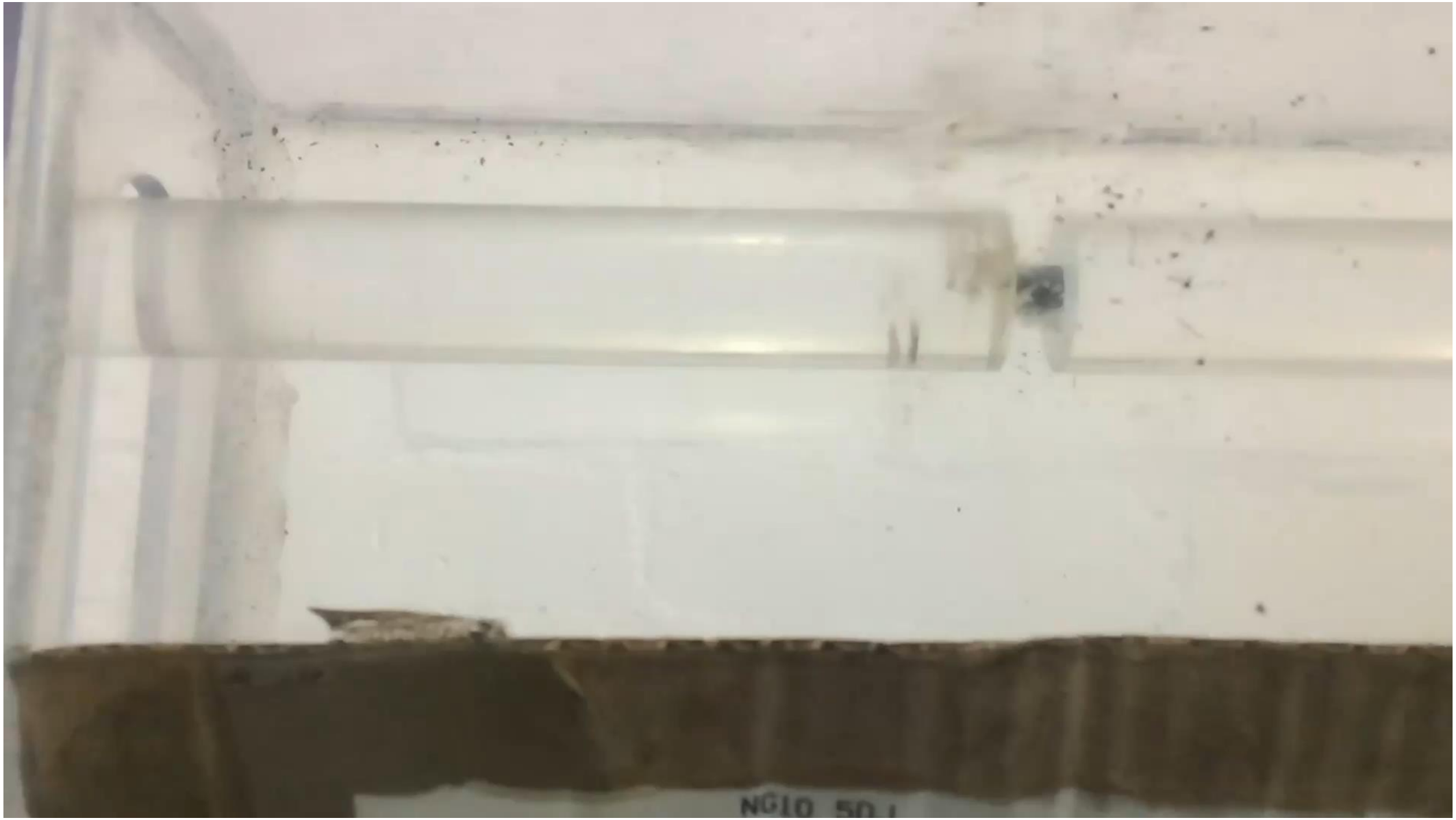
SHPB Slow Motion



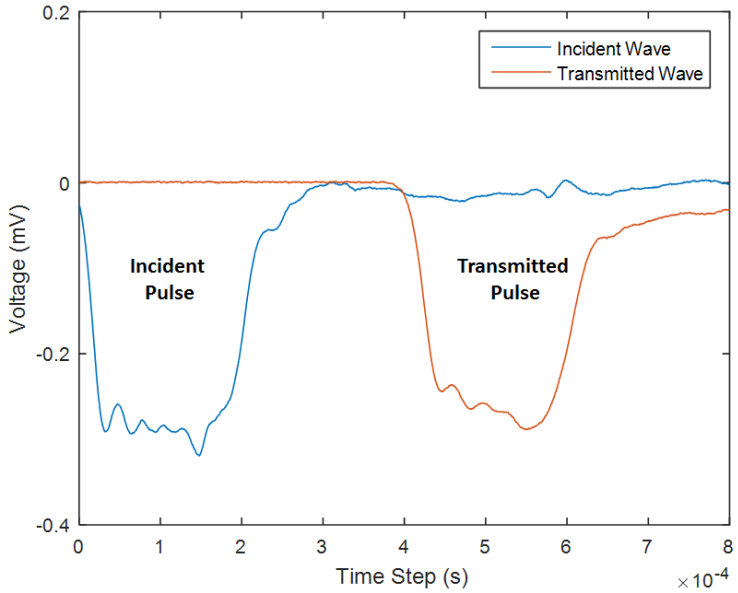
SHPB Outputs

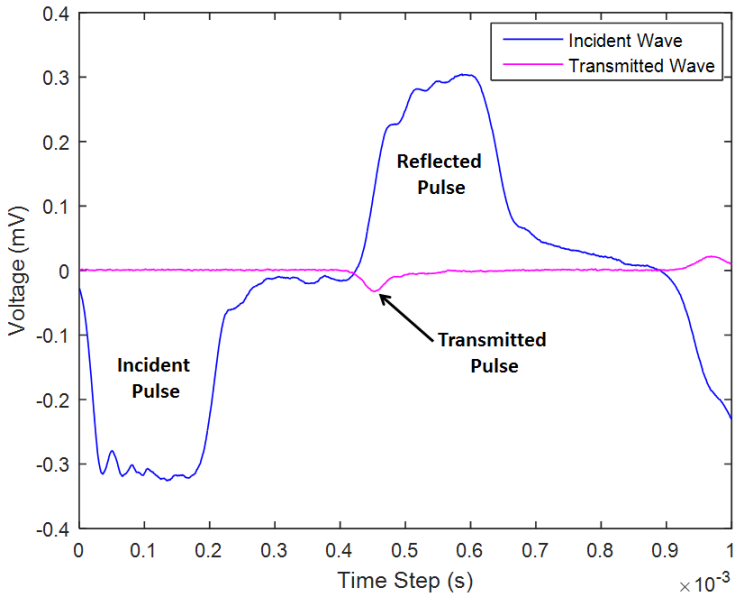
- Impact creates strain single which is converted into voltage output
- Engineering strain is obtained from:

$$e_s(t) = 2\frac{C_b}{L_s}\int_0^t \varepsilon_R dt$$

- Engineering stress is obtained from:

$$s_s(t) = \frac{A_B}{A_s} E_b \varepsilon_T(t)$$





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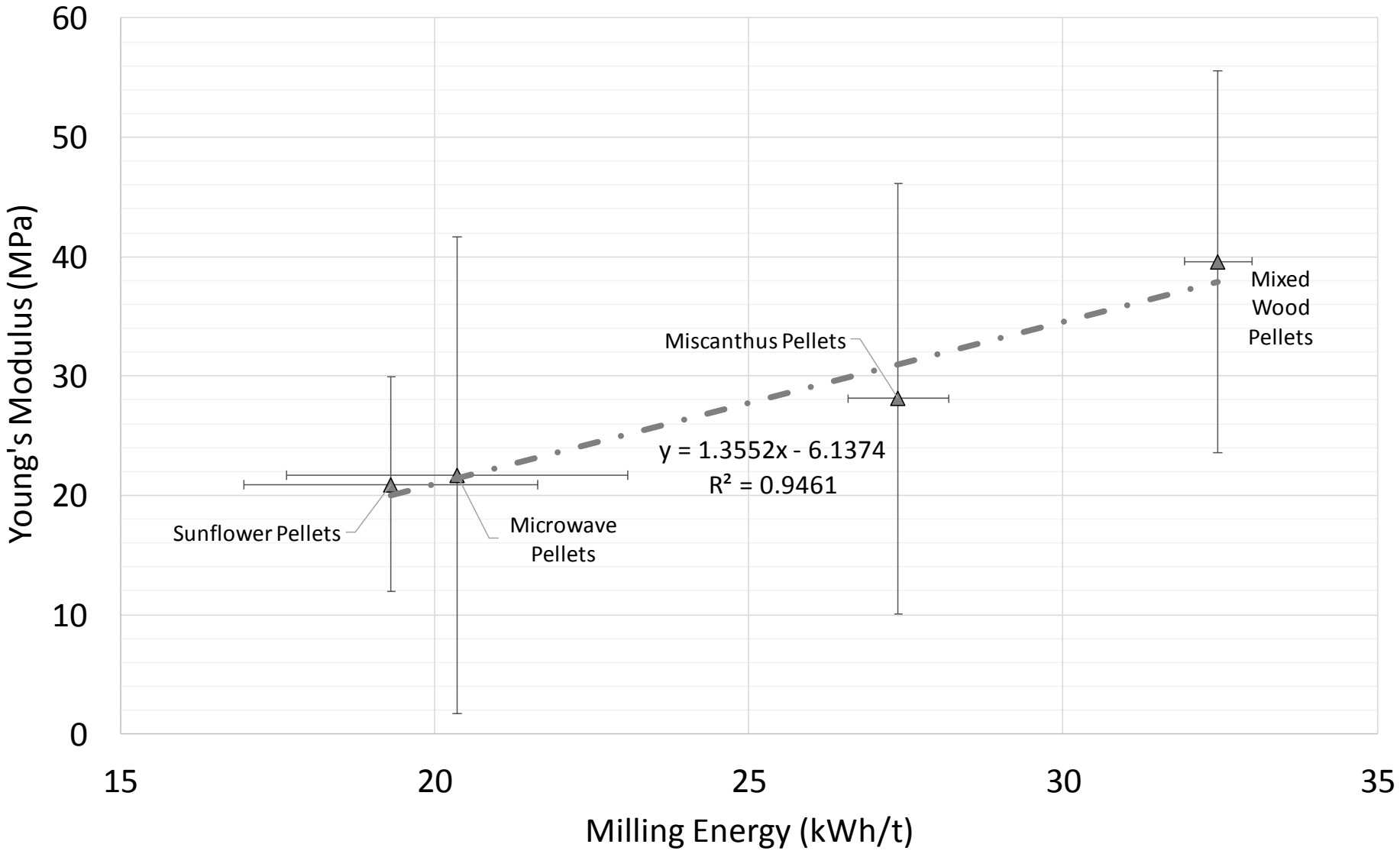
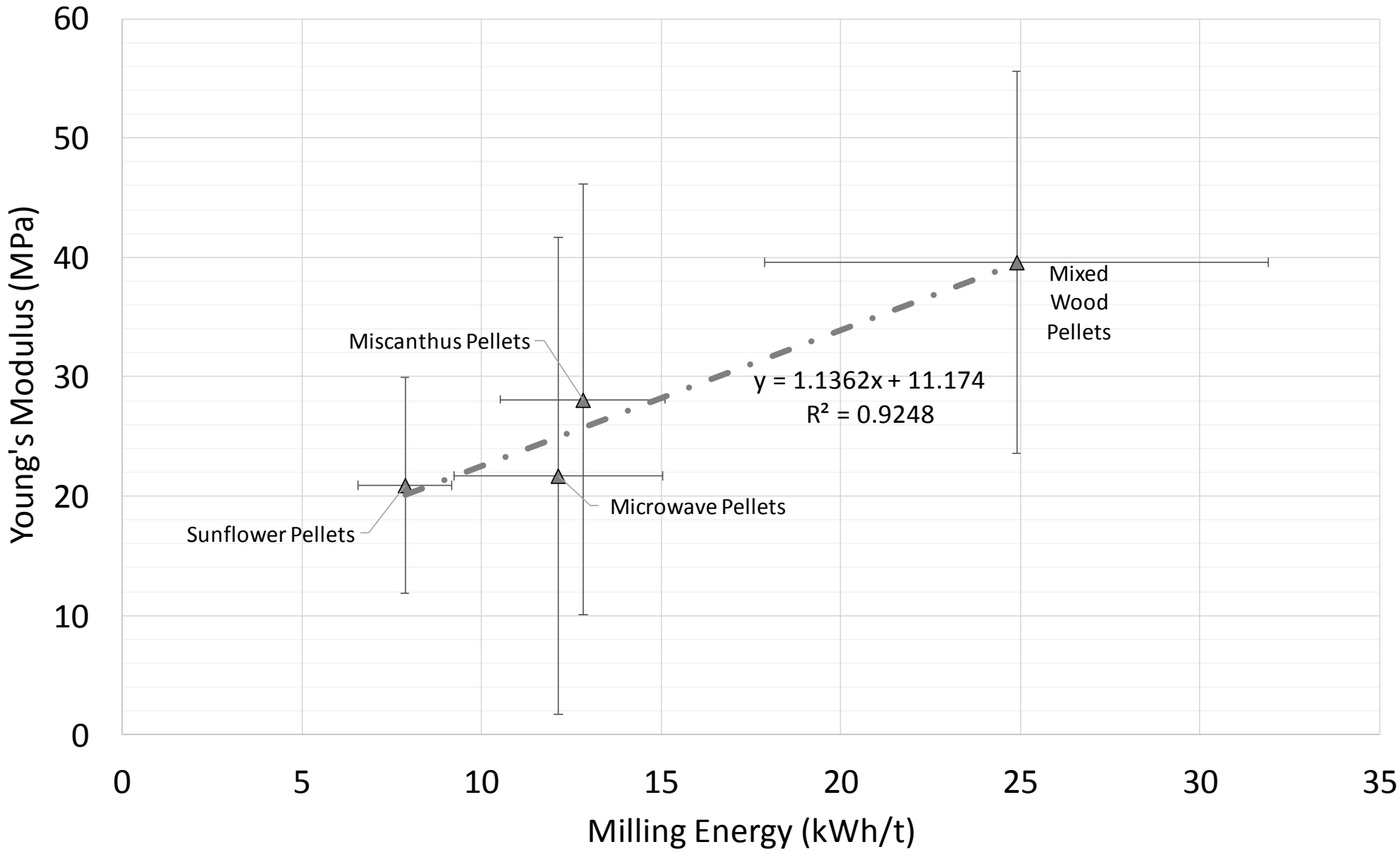
Correlation between Axial Young's Modulus and Knife Milling Energy



Correlation between Axial Young's Modulus and Ring-Roller Milling Energy



Conclusions

- The pellet durability correlated with HGI (provided the pellet durability was over 97.5%) and the milling energies from a knife mill and ring-roller mill
- Low durability will result in pellets that are unsuitable for transport and comminution.
- The compressive strength of the biomass pellets at low and high strain rates and in multiple orientations was obtained using quasi-static and dynamic mechanical tests.
- At low strain rates, the biomass pellets showed the highest rigidity in axial orientations under a uniformly distributed load (axial and diametral orientations), and poor rigidity when subjected to point loads (flexure test).
- Dynamic mechanical strength and rigidity were highest in the diametral orientation.

Conclusions

- Pellet strength was greater at high strain rates than at low strain rates.
- Orientation was an important factor in relating mechanical strength to milling energy.
- Correlations were only observed in the diametral orientation at low strain rates and in the axial orientation at high strain rates.
- Different torrefaction methods have varying impacts on pellet strength.
- Mechanical tests of biomass pellets can provide an indication of how a pellet will break down in the mill, but further work is required to enhance their accuracy for commercially produced biomass pellets.

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Thank you for listening

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