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Combustion of single particles of Balsa, European Ash and Oak

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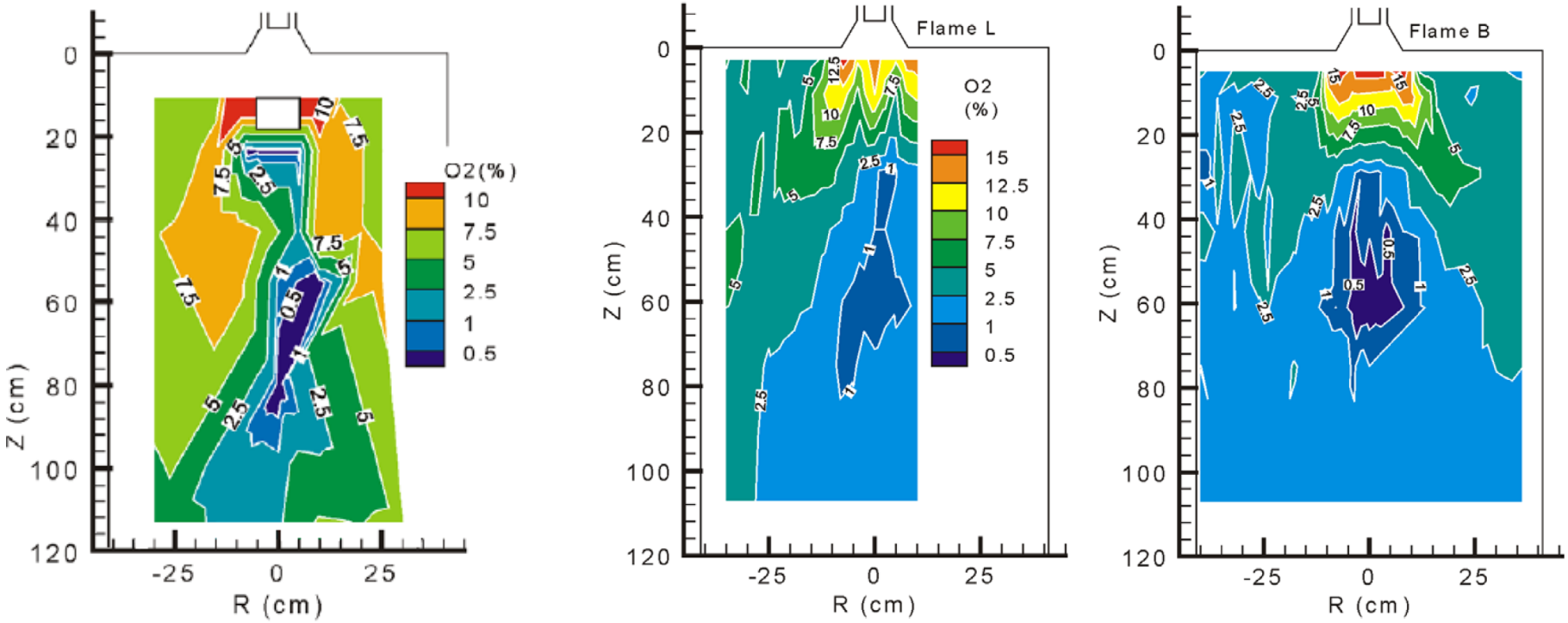
Co-firing biomass with coal



Oak

Lignite

Bituminous Coal

Near burner oxygen concentrations (note different oxygen scale in oak flame)

Ballester et al. Combustion and flame 141 (2005) 204-15.

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What biomass properties can we vary?

Physically possible to change the:

- Mass
- Shape
- Moisture content
- Fuel type
- Density

Economically possible to change the:

- ?
- ?
- ?
- Fuel type?
- Density?

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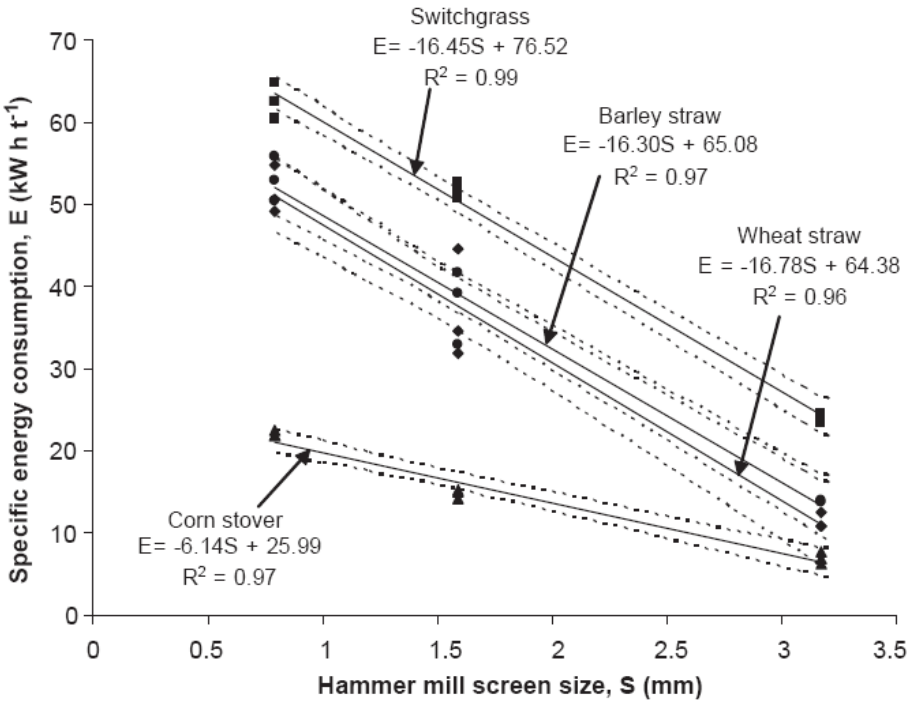
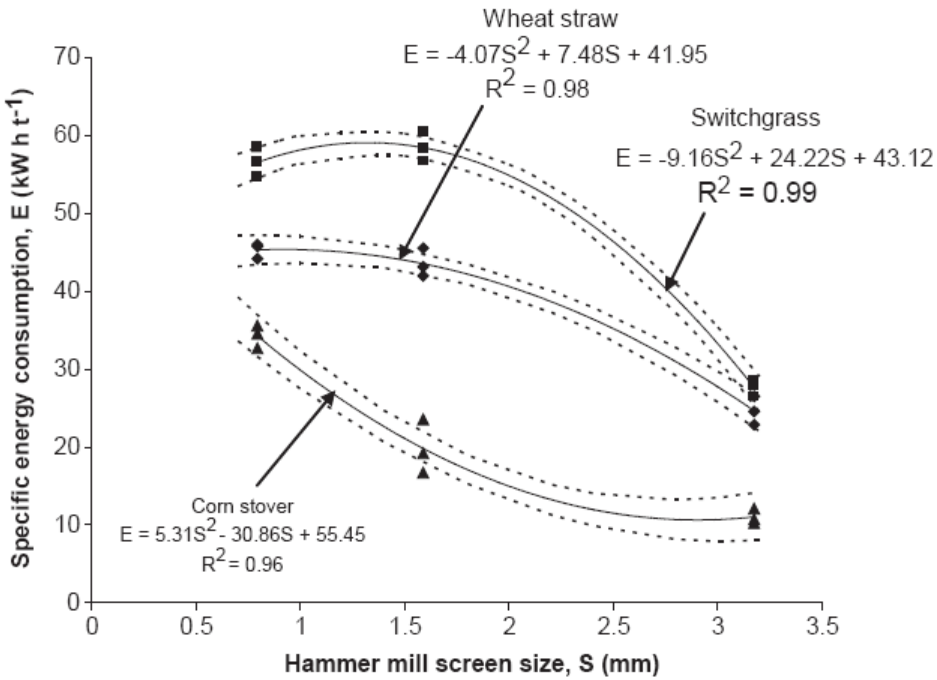
Energy requirement of biomass milling



8% Moisture



12% Moisture

Mani et al. Biomass and Bioenergy 27(4) (2004) 339-52.

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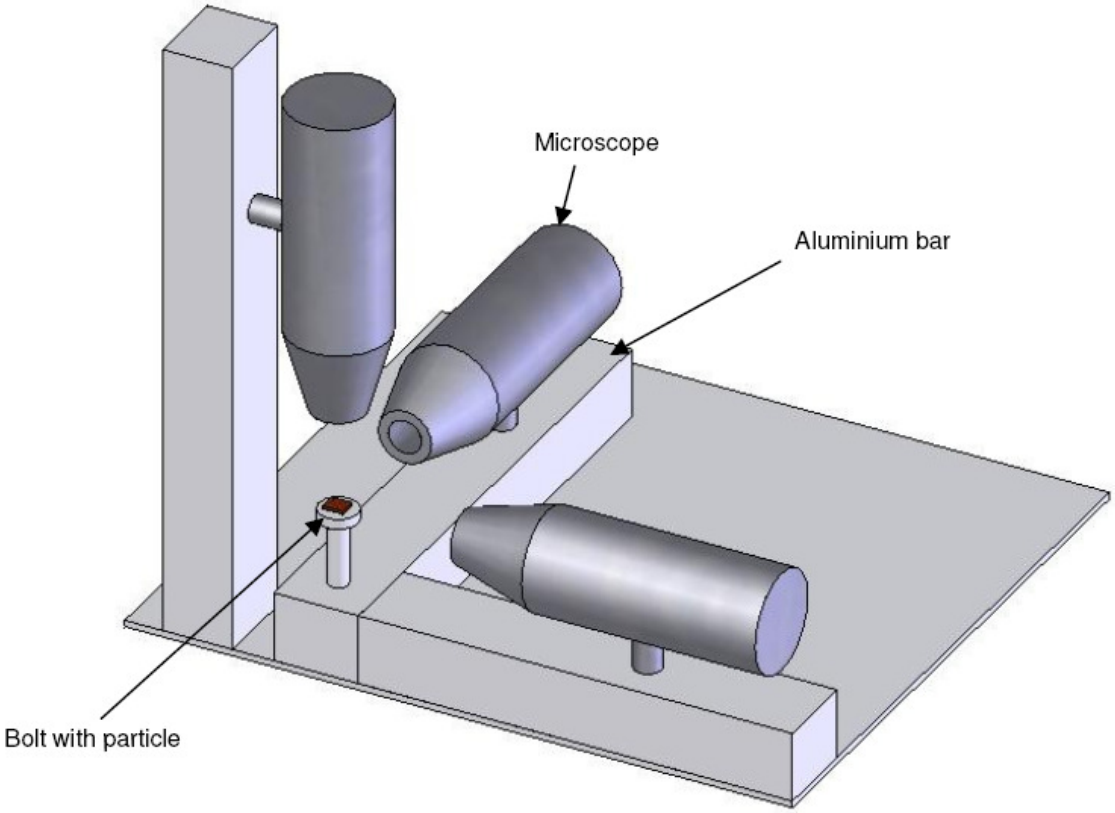
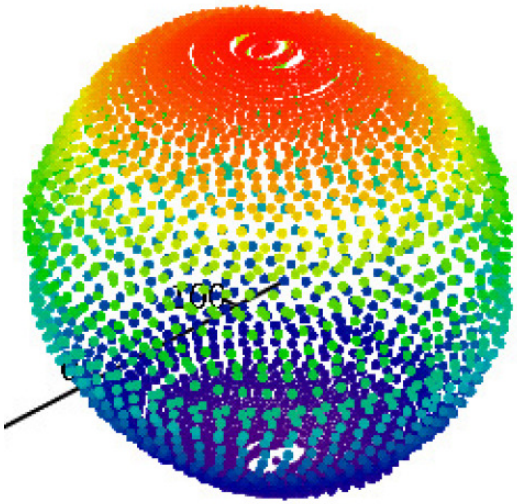
Shape, volume and surface area analysis





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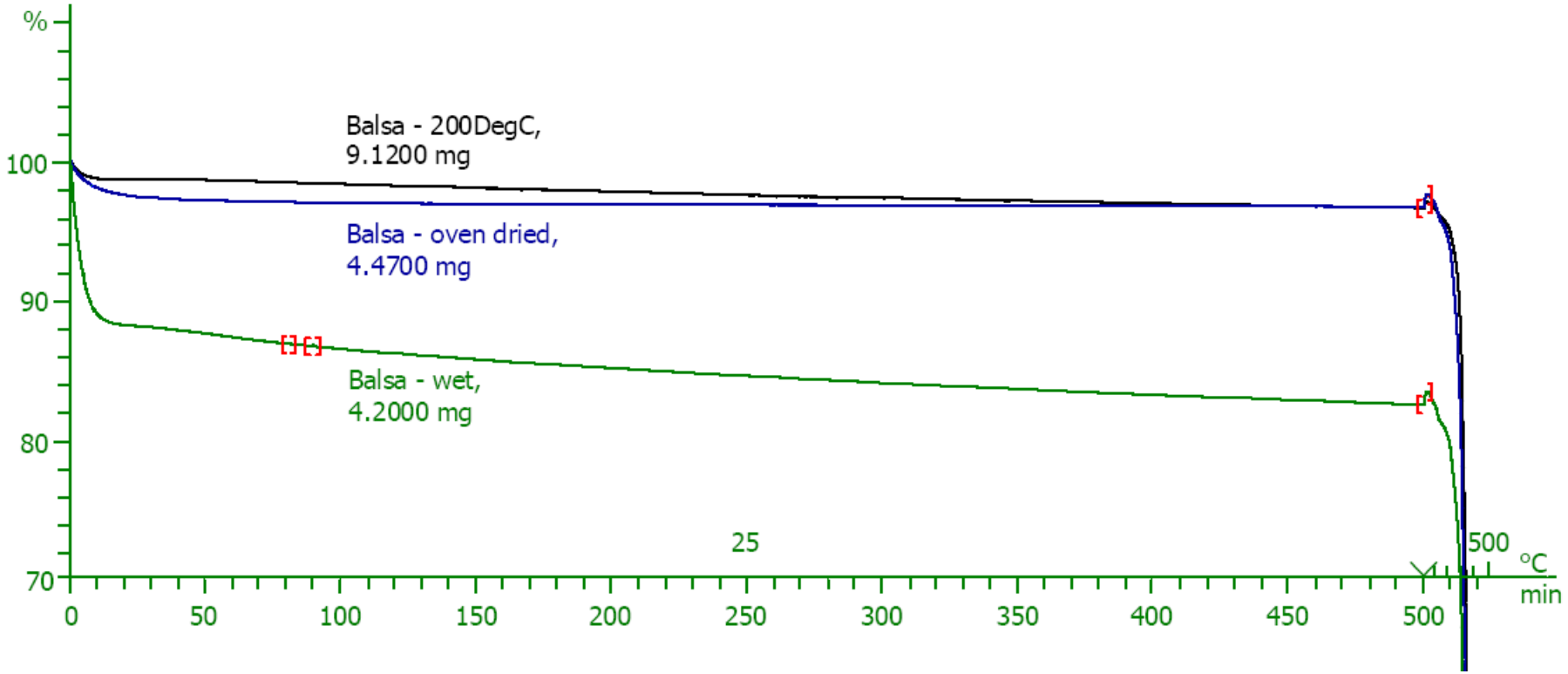
Moisture analysis



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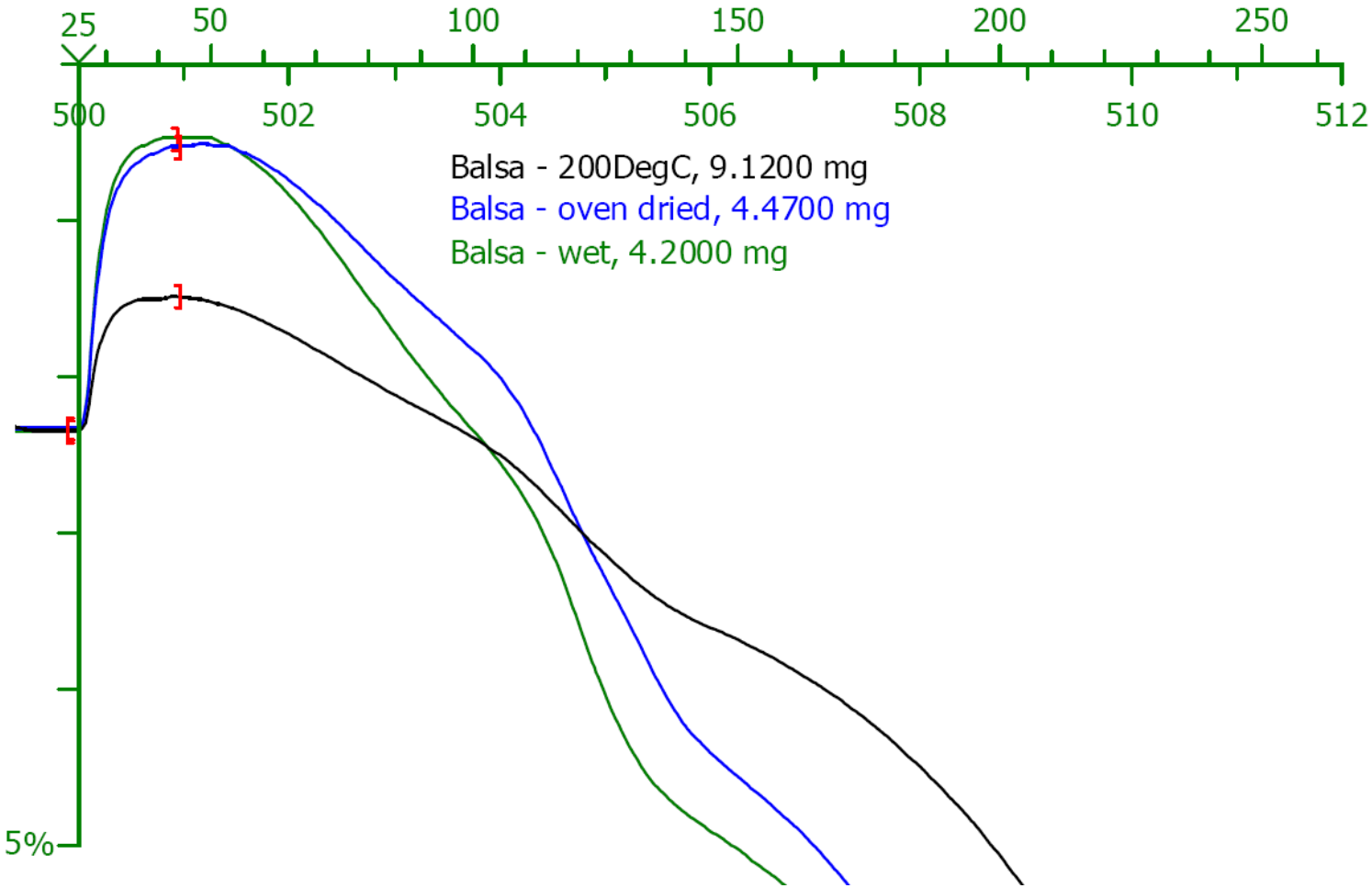
Moisture analysis



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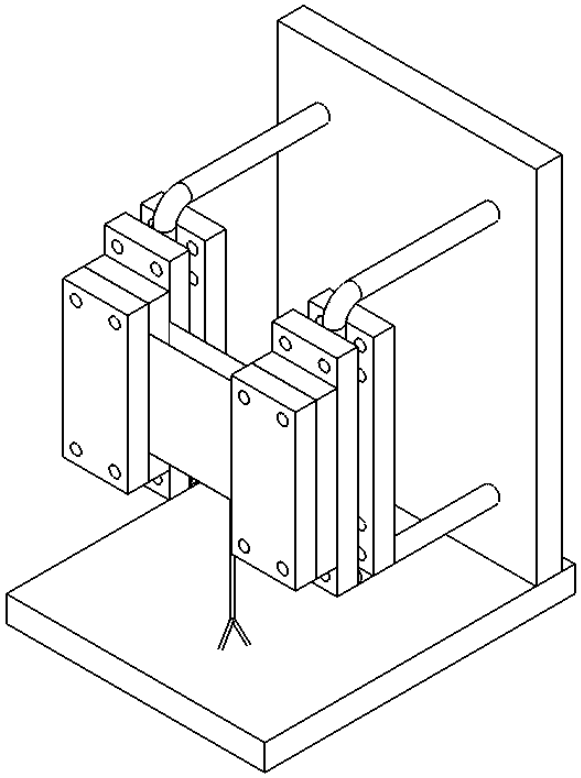
Wire mesh apparatus



Vertically orientated wire mesh designed to heat a thermocouple (positioned near particle) to 900ºC.

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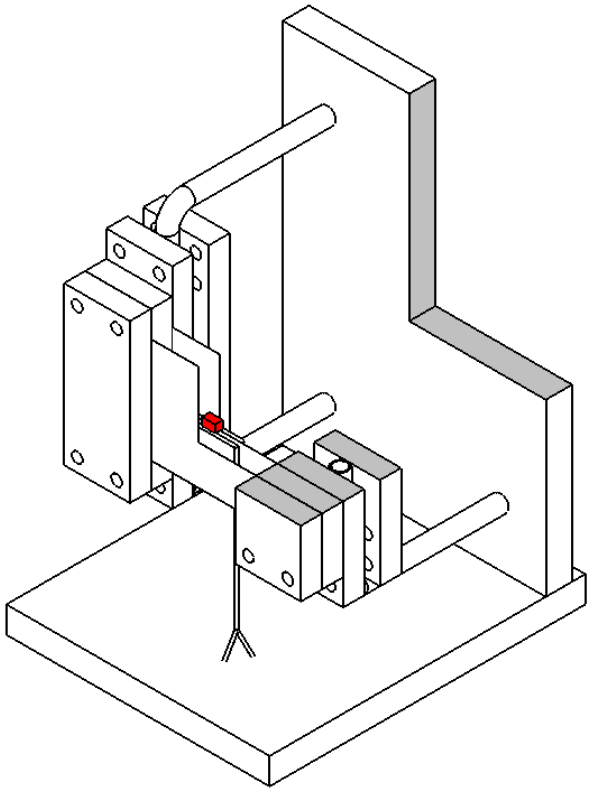
Wire mesh apparatus



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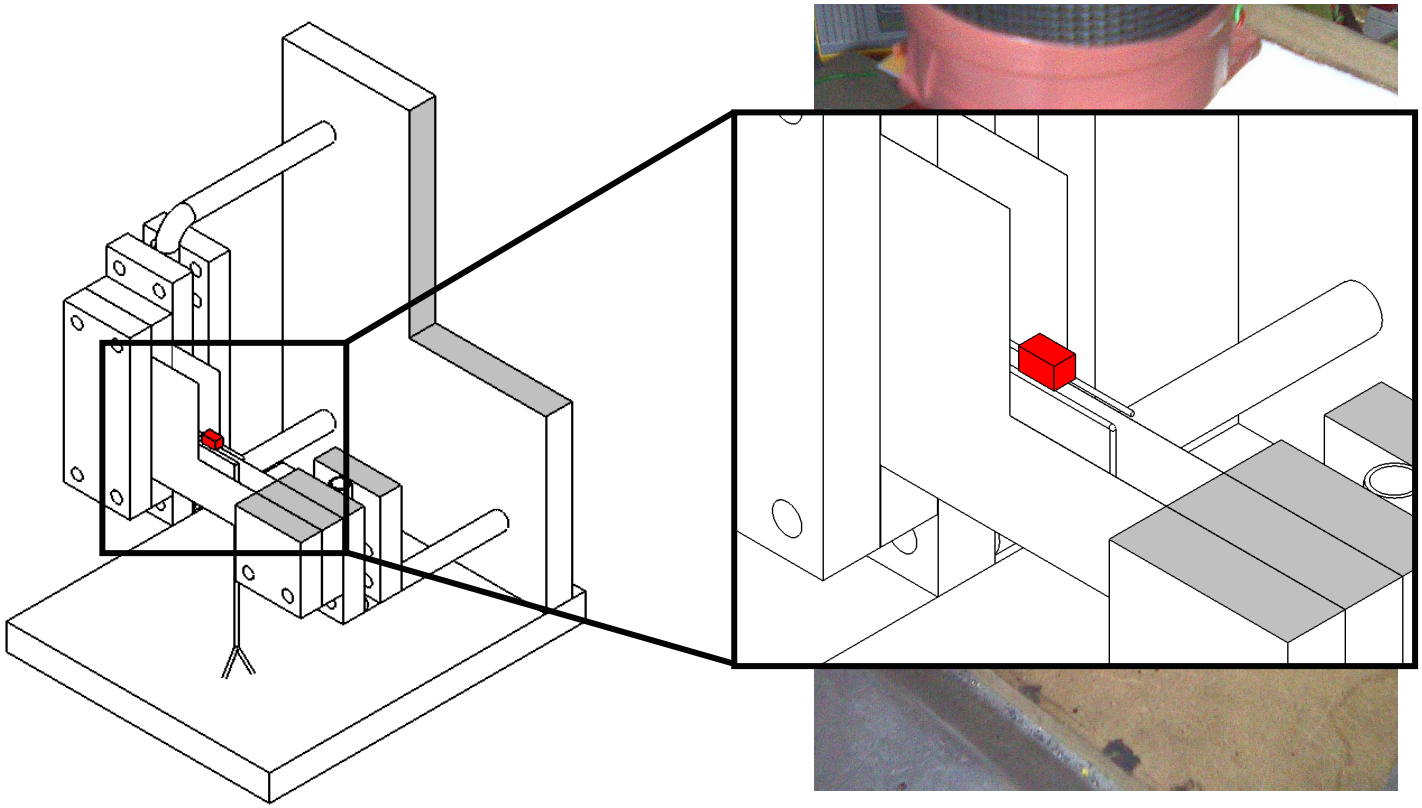
Wire mesh apparatus



Particles of around 2-5mm in size are loaded between the meshes before the heating cycle is started.

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Oak combustion

Oak, 23.4% Moisture, 20.38mg, Shape of 0.76, 35mm^3.

11-08-09_11-55.avi

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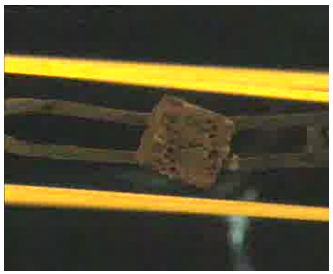
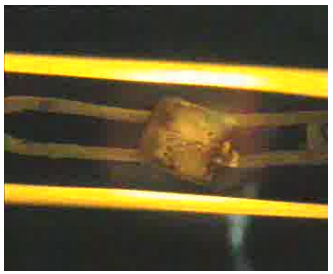
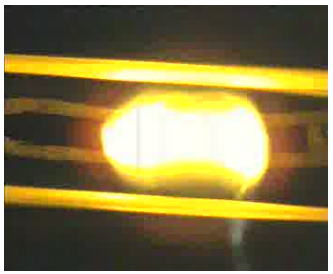
Oak combustion


0.40s


0.92s


2.48s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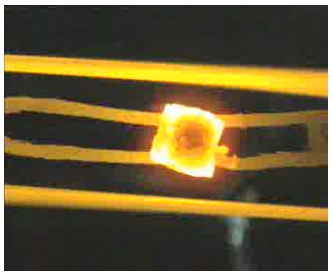
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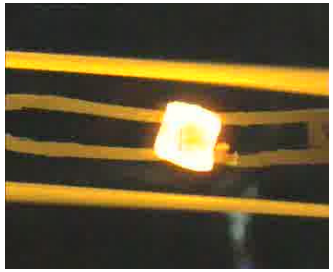
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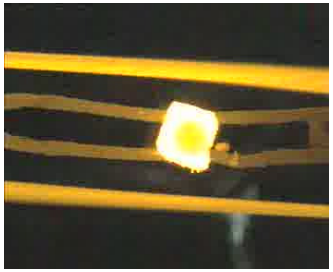
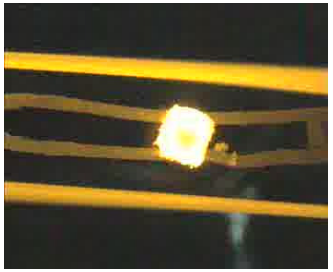

11.92s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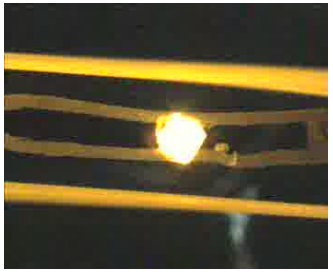
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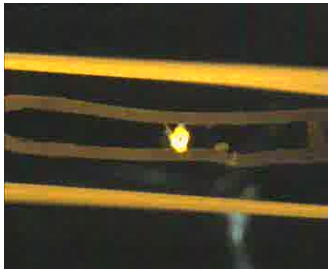
17.92s

Oak, 23.4% Moisture, 20.38mg, Shape of 0.76, 35mm^3.

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Combustion experiments

	Low moisture content (dried at 205ºC)	Low moisture content (dried at 105ºC)	High moisture content (equilibrium at near 100% RH)
Balsa	16	14	13
European Ash		30	24
Oak		14	21

Also intend to burn more fuels – Straw, Miscanthus, PKE

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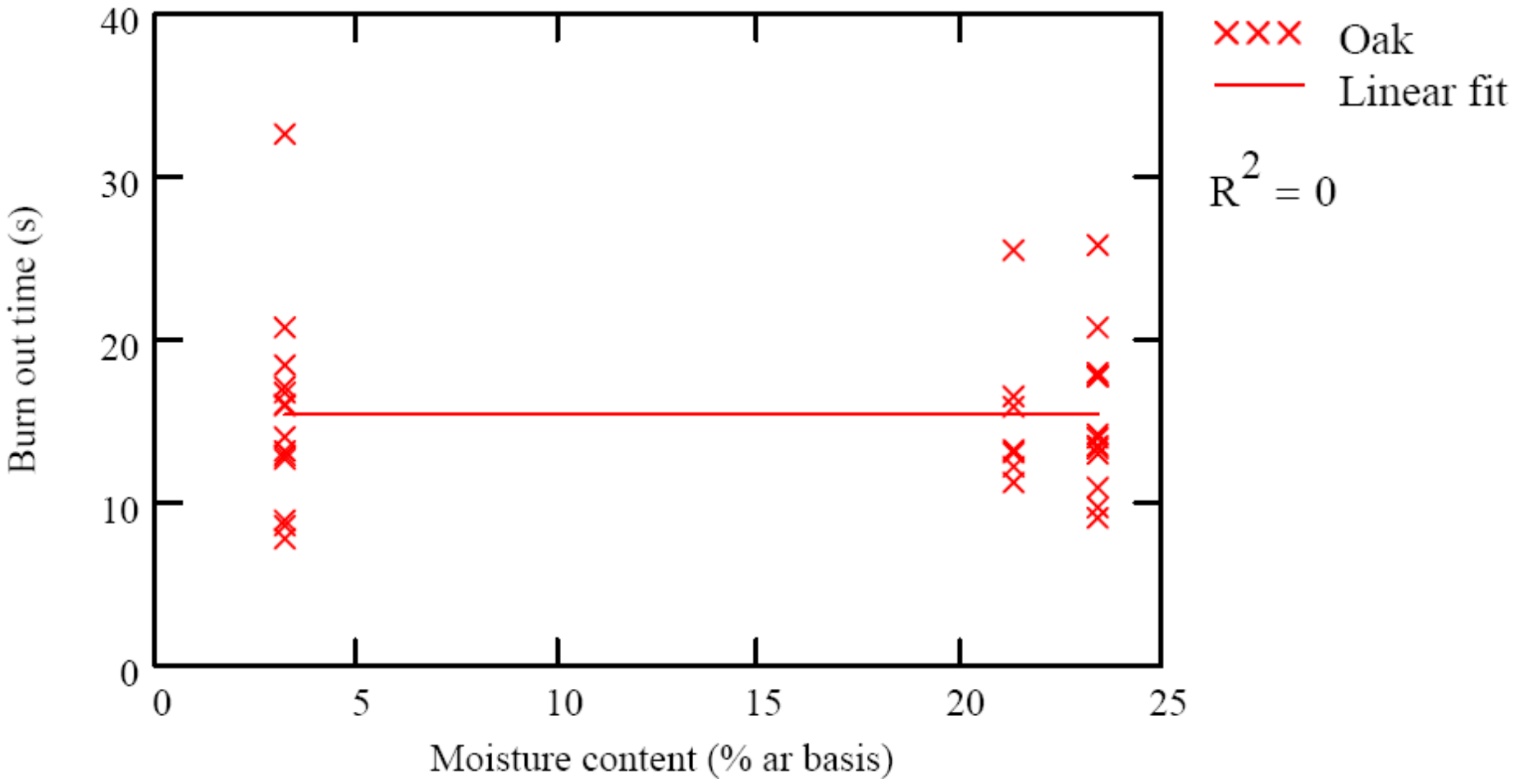
Burn out time – Oak – Effect of moisture



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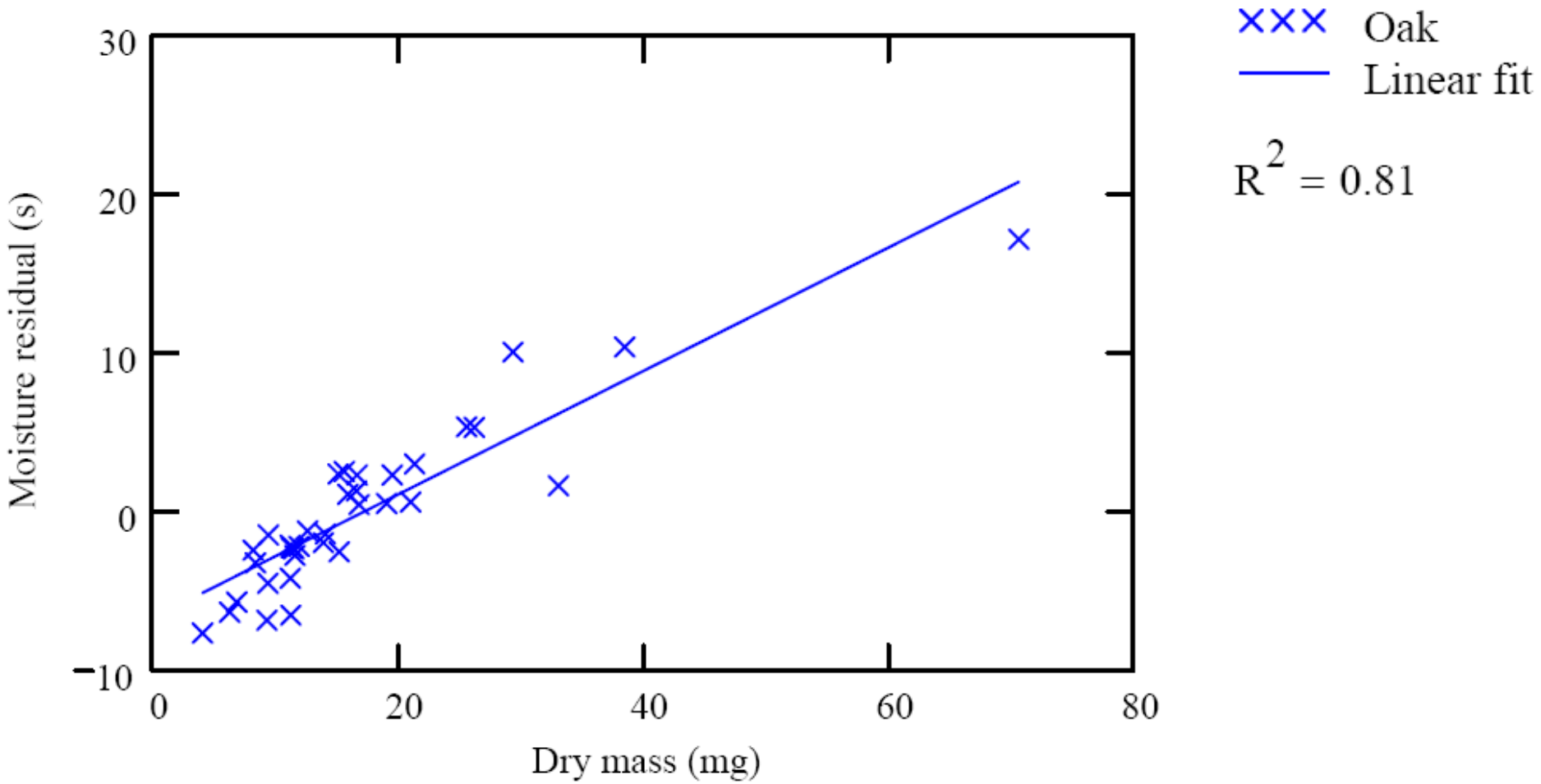
Burn out time – Oak – Effect of dry mass



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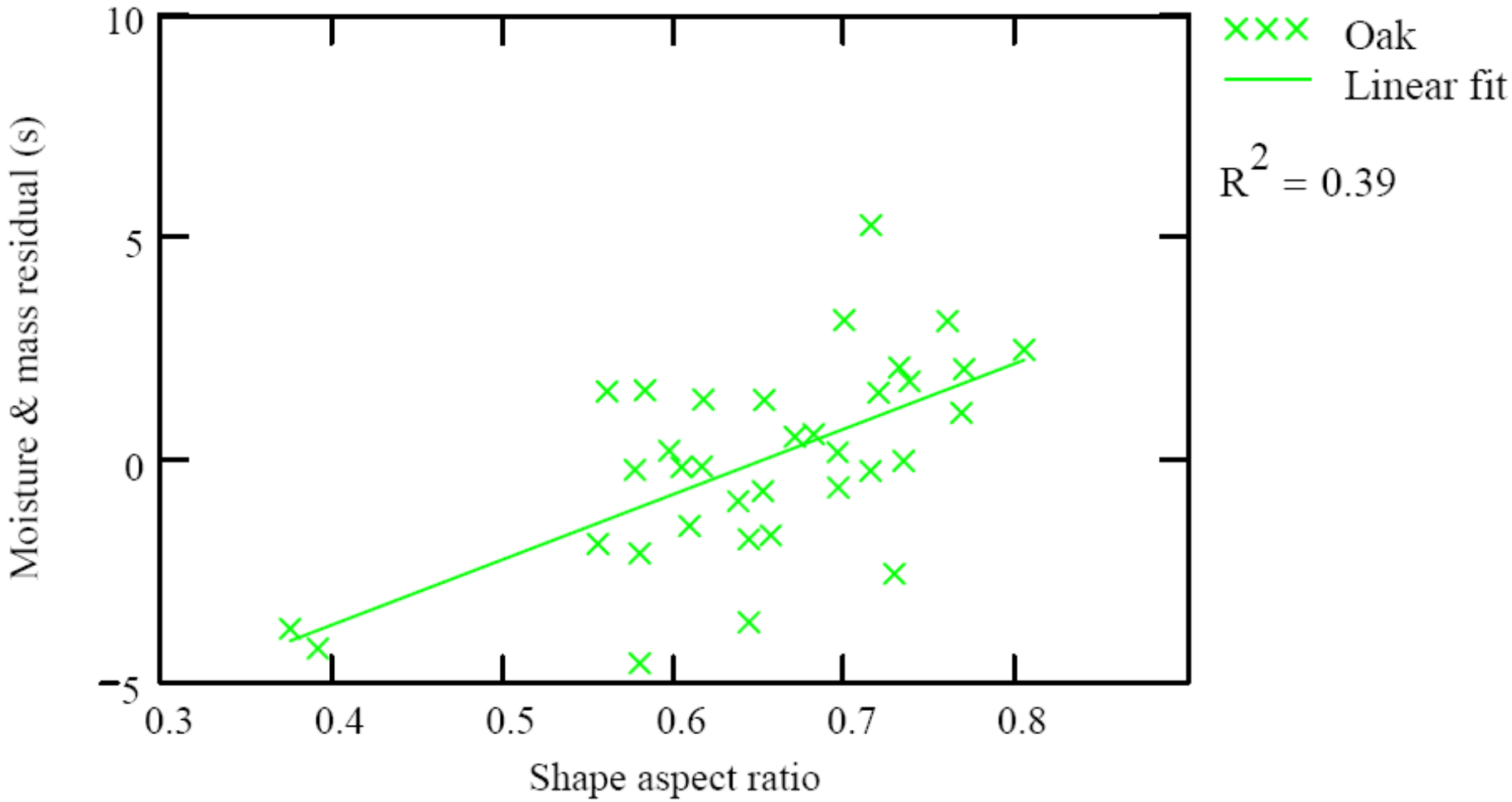
Burn out time – Oak – Effect of shape aspect ratio



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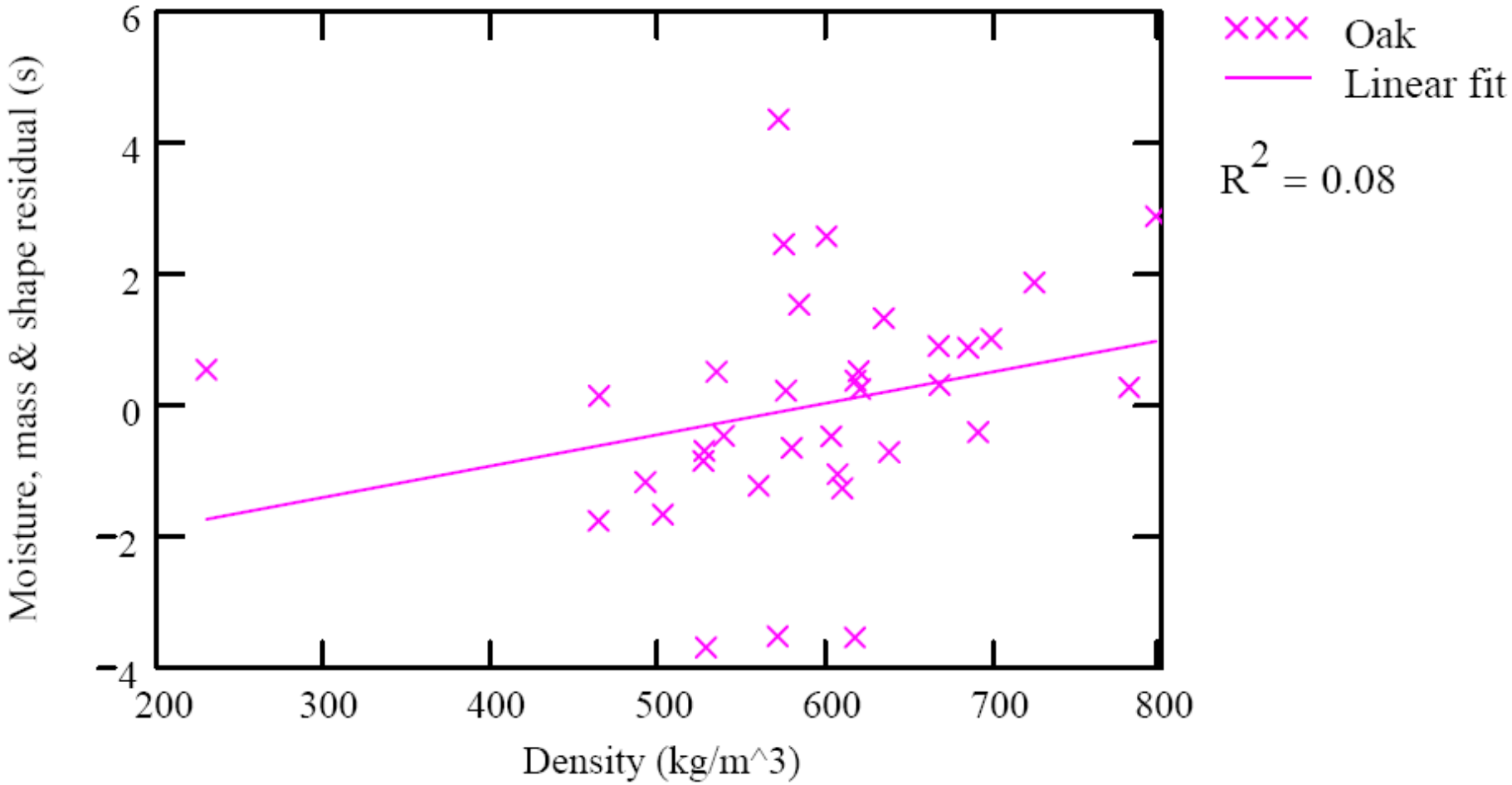
Burn out time – Oak – Effect of density



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Burn out time – Oak – Regression model

Combining the above linear trends we can form a regression model:

Burn out time (s) =		$-1.32*10^{-3}$	*	Moisture content (%)	+	15.46
	+	0.389	*	Dry mass (mg)	-	6.65
	+	14.7	*	Shape aspect ratio	-	9.58
	+	$4.77*10^{-3}$	*	Density (kg/m^3)	-	2.82

This should account for 89% of the variation in the data set.

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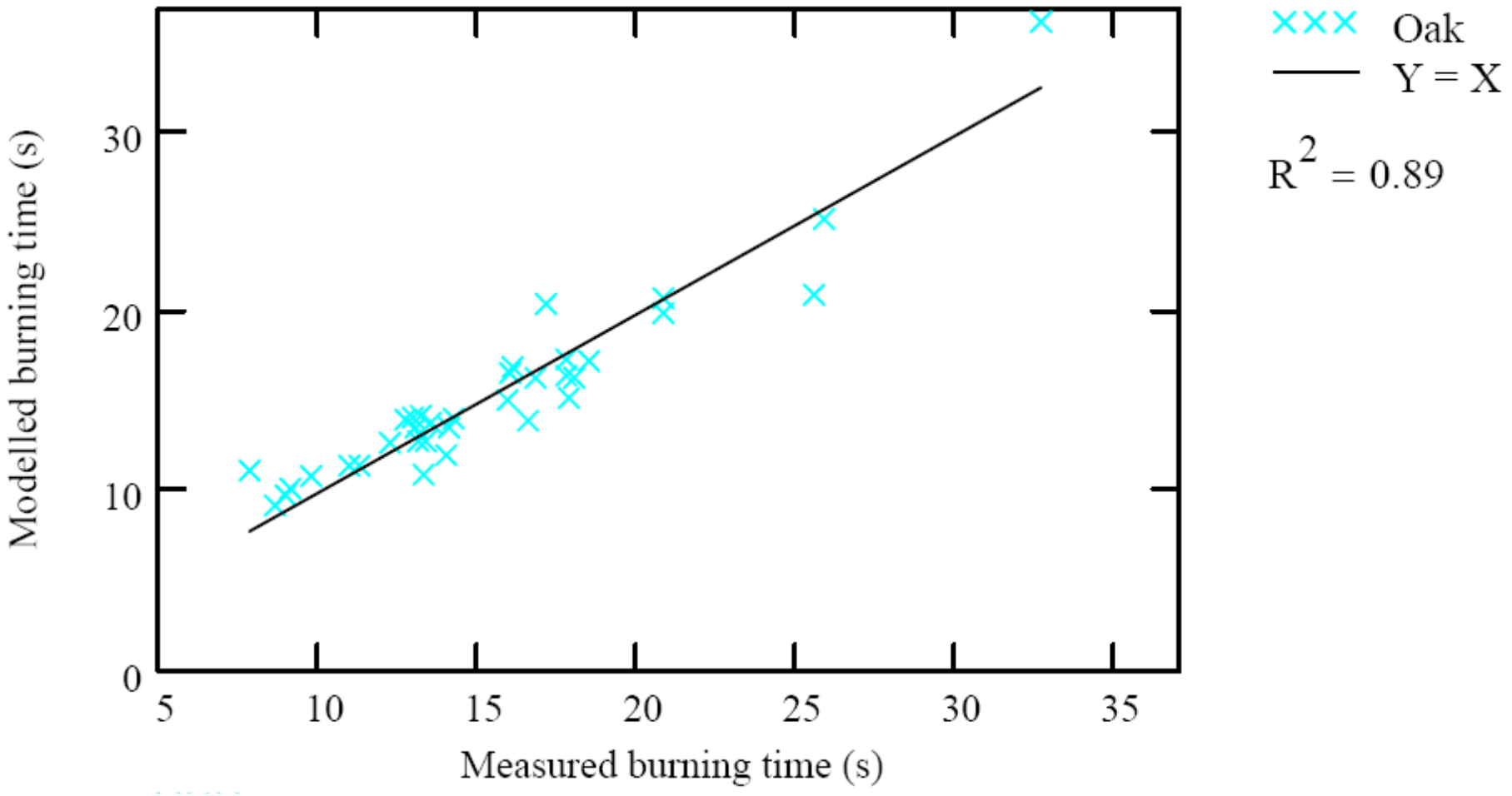
Burn out time – Oak – Regression model



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European Ash - Strength of effects

	Measured drying time	Devolatilisation ending time	Particle burn out time
Variation due to effect of moisture	0.63	0.10	0.04
Variation due to effect of dry mass	0.126	0.576	0.739
Variation due to effect of shape	0.010	0.211	0.097
Variation due to effect of density	No data	No data	No data
Variation which cannot be accounted for	0.234	0.113	0.124

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Oak - Strength of effects

	Measured drying time	Devolatilisation ending time	Particle burn out time
Variation due to effect of moisture	0.55	0.18	0.00
Variation due to effect of dry mass	0.072	0.459	0.81
Variation due to effect of shape	0.064	0.159	0.074
Variation due to effect of density	0.019	0.038	0.009
Variation which cannot be accounted for	0.295	0.164	0.107

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Balsa - Strength of effects

	Measured drying time	Devolatilisation ending time	Particle burn out time
Variation due to effect of moisture or heat treatment	0.10	0.02	0.18
Variation due to effect of dry mass	0.018	0.55	0.52
Variation due to effect of shape	0.0088	0.034	0.012
Variation due to effect of density	0.323	0.032	0.064
Variation which cannot be accounted for	0.55	0.364	0.224

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Conclusion

Combustion behaviour of Balsa, European Ash and Oak have been studied in a single particle wire mesh apparatus.

Drying times were found to depend upon moisture content, although there is some unexplained variation in the results

Devolatilisation ending times were found to primarily depend upon dry mass, but also shape and to a lesser extent moisture content.

Burn out times were found to depend heavily upon dry particle mass (i.e. and not much else).

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Questions?

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