AIR PERMEABILITY OF THE LITTER LAYER IN TEMPERATE FORESTS OF SOUTH-EAST AUSTRALIA

bushfire&natural HAZARDSCRC

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FUEL ON THE GROUND, SUCH AS LEAVES, TWIGS AND DECOMPOSING MATTER, ACCUMULATE OVER TIME AND ACCOUNT FOR A LARGE PERCENTAGE OF THE TOTAL FUEL LOAD IN FORESTS. THE AIR PERMEABILITY OF THE LITTER LAYER IS A CRITICAL FACTOR THAT INFLUENCES FIRE BEHAVIOUR BECAUSE THE AIR PERMEABILITY CONTROLS THE AMOUNT OF OXYGEN AVAILABLE FOR THE COMBUSTION IN THE FUEL BED.

BACKGROUND

In fire events, the litter layer is often referred to as the fuel bed.

There are two types of combustion processes that can occur in the fuel bed: smouldering and flaming combustion.

It has been shown in our previous study, the oxygen availability has significant effects on the combustion regimes in a fuel bed.

The oxygen availability in a fuel bed is dependent of the air permeability of that fuel bed.

RESEARCH QUESTION

What is the air permeability of the litter layer?

METHODOLOGY

An experimental testing rig (Fig. 1) was designed to determine the permeability of a fuel bed by measuring the pressure drop across the fuel bed.

The experiments were conducted on two groups of samples: milled biomass fuel bed and forest litter layer.

The milled biomass and litter layer particles were sieved.

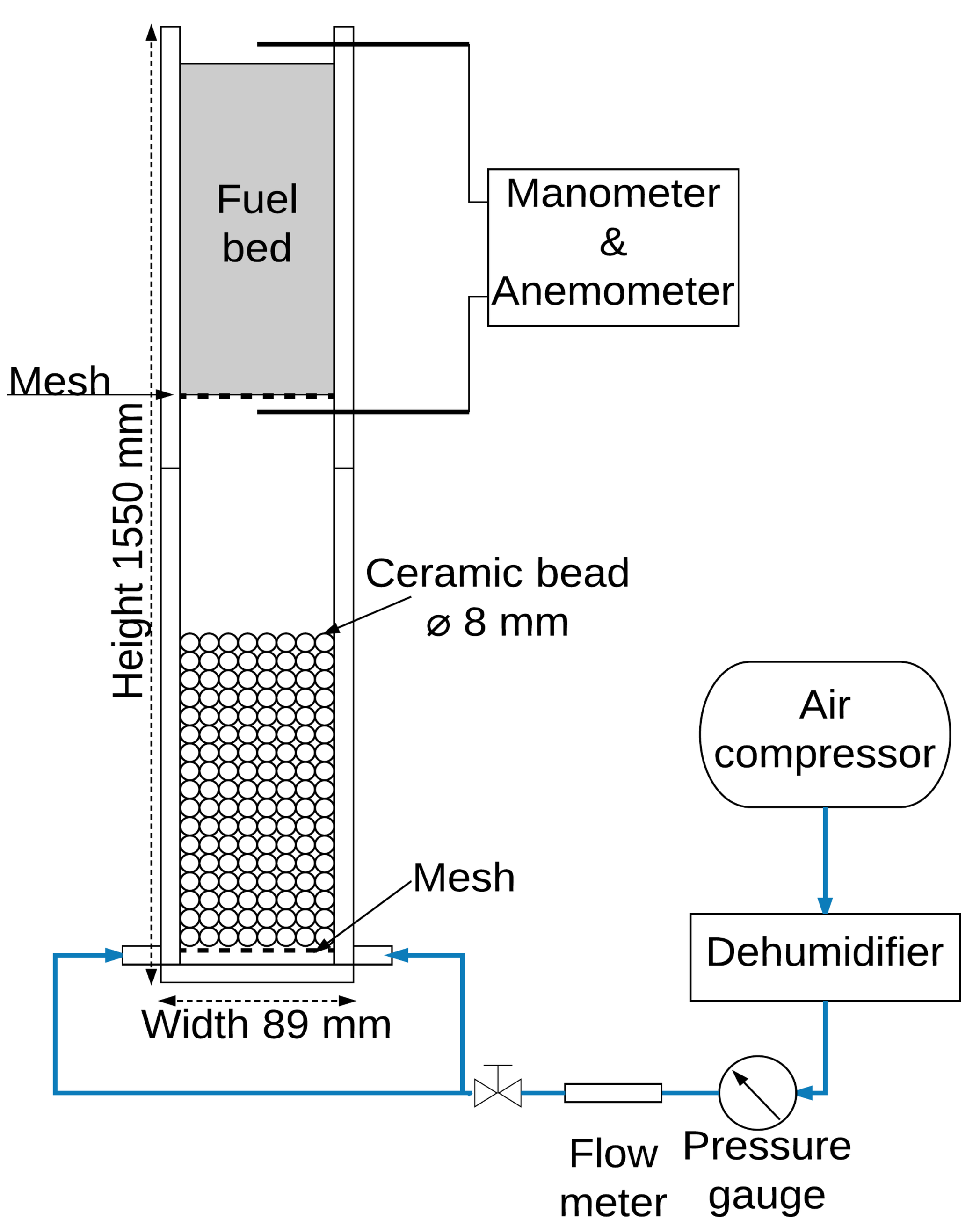

Figure 1: *Schematic diagram of Permeability testing rig*

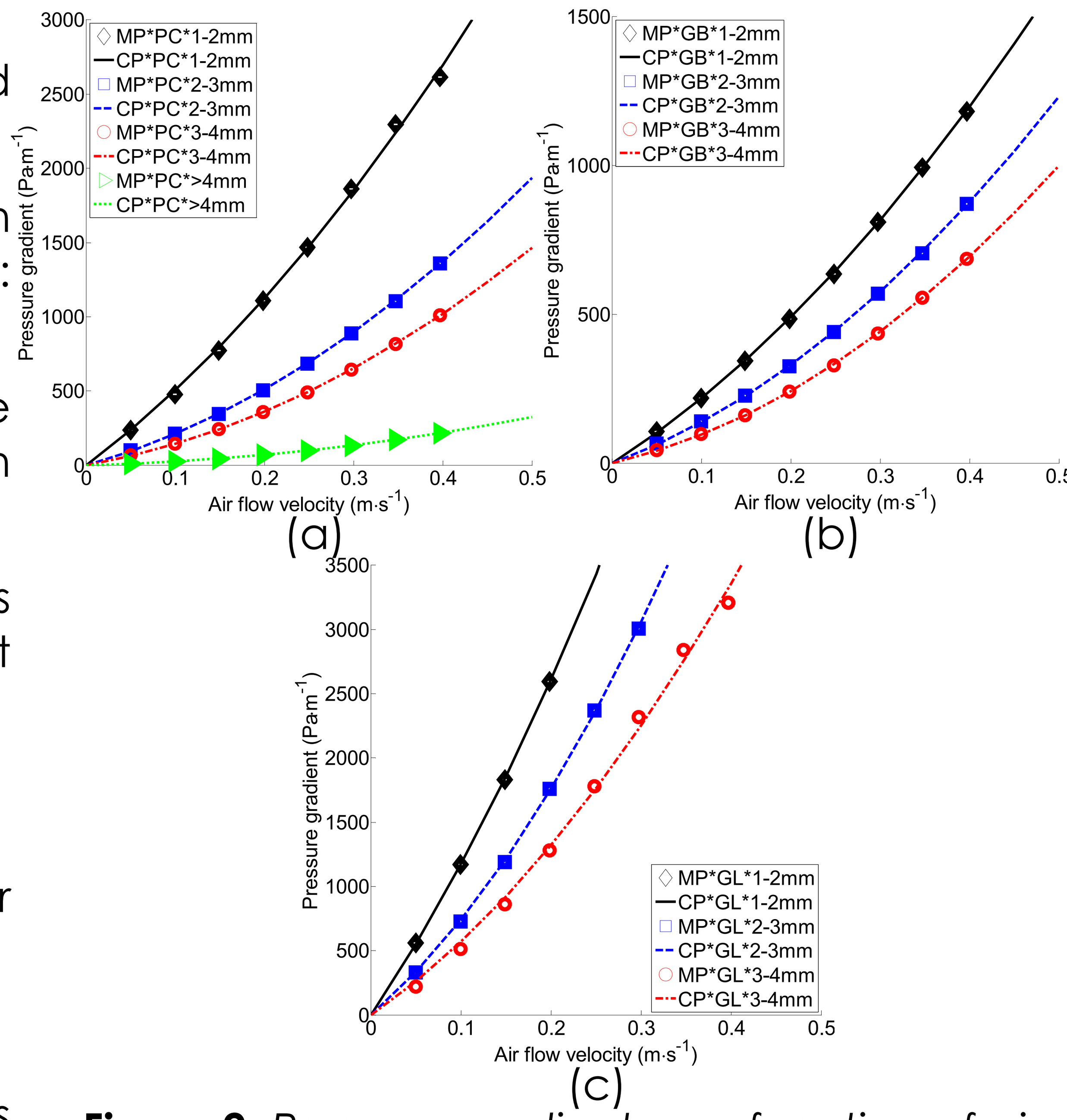

Figure 2: *Pressure gradient as a function of air flow velocity for particles: (a) Pine chips(PC) (b) Gum bark(GB) (c) Gum leaf(GL); Measured pressure gradient (MP); Calculated pressure gradient (CP).*

PRESSURE GRADIENT VERSUS AIR VELOCITY

Fig 2. shows the pressure gradient of three milled biomass fuel beds as a function of air flow velocity for different particle sizes. The relationship between the gradient and air flow velocity is close to a positive linear relationship. A similar trend was also observed in the forest litter layer.

FORCHHEIMER EQUATION

The permeability of fuel bed and Forchheimer coefficient (non-Darcy flow coefficient) were determined using the Forchheimer equation based on the measured pressure drop across the fuel bed from the permeability testing rig (Fig 1.). Forchheimer coefficient is an essential parameter for defining a porous medium in a computational fluid dynamics model.

PERMEABILITY

The permeability of the milled biomass fuel bed and forest litter layer is summarised in Table 1. The results show that the permeability increases with increasing particle size, **(Cont.)**

Milled biomass fuel bed	*Forchheimer permeability ($\times 10^{-11}$ m^2)*	*Forest litter layer**	*Forchheimer permeability ($\times 10^{-11}$ m^2)*
PC, 1-2 mm	4.83	Twig, <5 mm#	1198.56
PC, 2-3 mm	6.75	Twig, 5-10 mm#	1013.30
PC, 3-4 mm	11.20	Twig, >10 mm#	1186.15
PC, 30 mm	87.07	Leaf	303.16
GB, 1-2 mm	6.02	DM, 1-2 mm	2.36
GB, 2-3 mm	7.35	DM, 2-3 mm	5.05
GB, 3-4 mm	21.31	DM, 3-4 mm	12.46
GB, 30 mm	394.88	DM, >4 mm	18.26
GL, 1-2 mm	1.11		
GL, 2-3 mm	1.99		
GL, 3-4 mm	2.89		
GL, 30 mm	248.76		

Table 1: *Permeability of the milled biomass samples (pine chips(PC); gum bark(GB); gum leaf(GL)) and the forest litter layer (Twig; Leaf; decomposing matter(DM)) #the diameter of twigs; *The litter layer sample was collected from a forest in East Gippsland, Victoria, Australia.*

(Cont.) except for twigs, where the permeability is close for different particle sizes. The leaf sample in the forest little layer has a similar permeability to the milled gum leaf with 30mm particle size. The decomposing matter samples' permeability is close to the one of the pine chips samples. The twig samples (3 sizes) have the highest permeability. Hence, the flaming combustion is most likely to occur in the twig layer.

CONCLUSION

The study adds knowledge to understanding how processes involving fuel bed particle size and air flow can influence fire behaviour. The importance of understanding these processes is imperative for fire managers because they have implications for flare ups in smouldering fuels and the choice of suppression options used during prescribed and wildfire operations

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