Additive Manufacturing Task Group: Progress on ULTEM 9085

International Aircraft Materials Fire Test Forum, June 11th, 2020

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Agenda

- Outline
- Results
- Discussion
- Next steps

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Outline

- Additive manufacturing allows for material modifications impossible with conventional production techniques. It is unclear to what extent these modifications alter the flammability behaviour
- A task group was founded at the FAA Materials Fire Test Forum in June 2018 to investigate the influence of printing parameters
- Decision to start with Fused Deposition Modelling (FDM) and Polyetherimide Ultem 9085 CG as both printers and material were available at different locations

Printing technology, materials and parameters

Part design

- "Replica" of conventional part
- Bio-inspired (bone-like) complex structures

Post processing

- For the specimen: e.g. removal of support, or for the part: e.g. grinding/sanding to certain surface quality
- Spatula, fillers, topcoats

Build

- Printing directions
- Raster angle
- Layer thickness
- Thickness
- Infill (%)
- Single specimens vs. cut from bigger plate

Manufacturing technology

- Fused Filament, laser sintering, powder bed etc.
- Printer manufacturer and type
- Layer thickness
- Print speed and temperature

Material

- Material itself is a variable
- ALM type vs. standard type of same material
- Filament thickness

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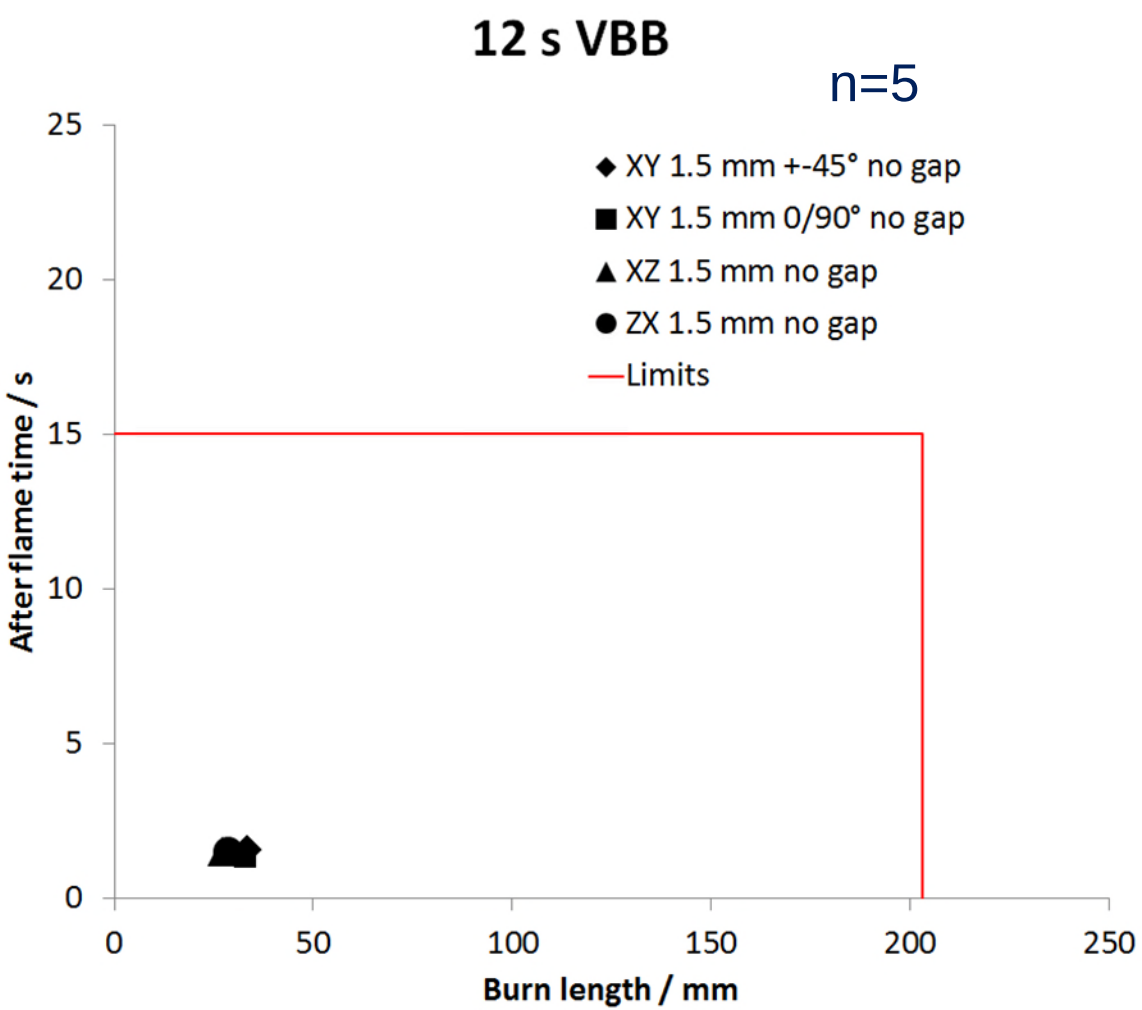
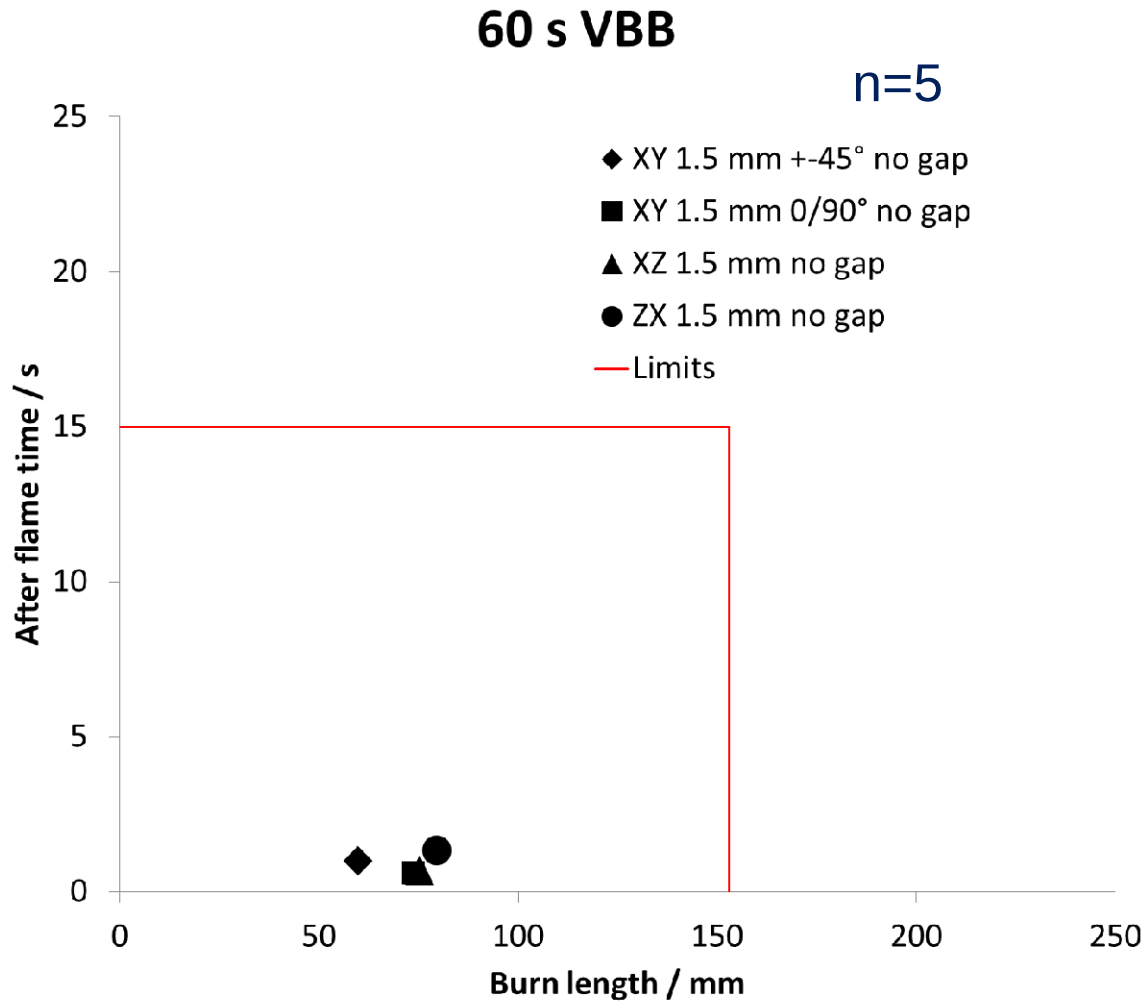
Results: 100% infill, influence of orientation





→ No influence of orientation for densest packing

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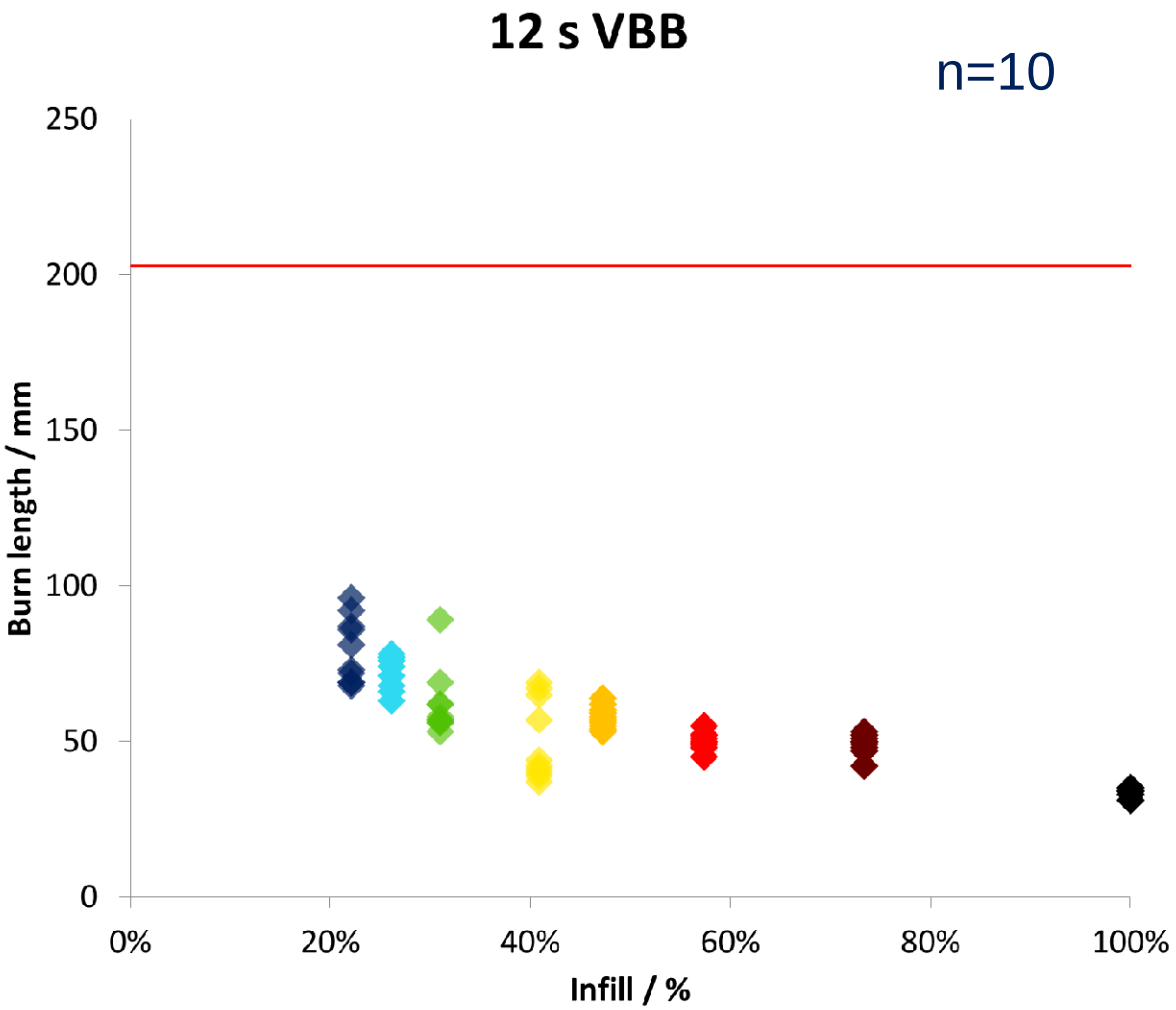
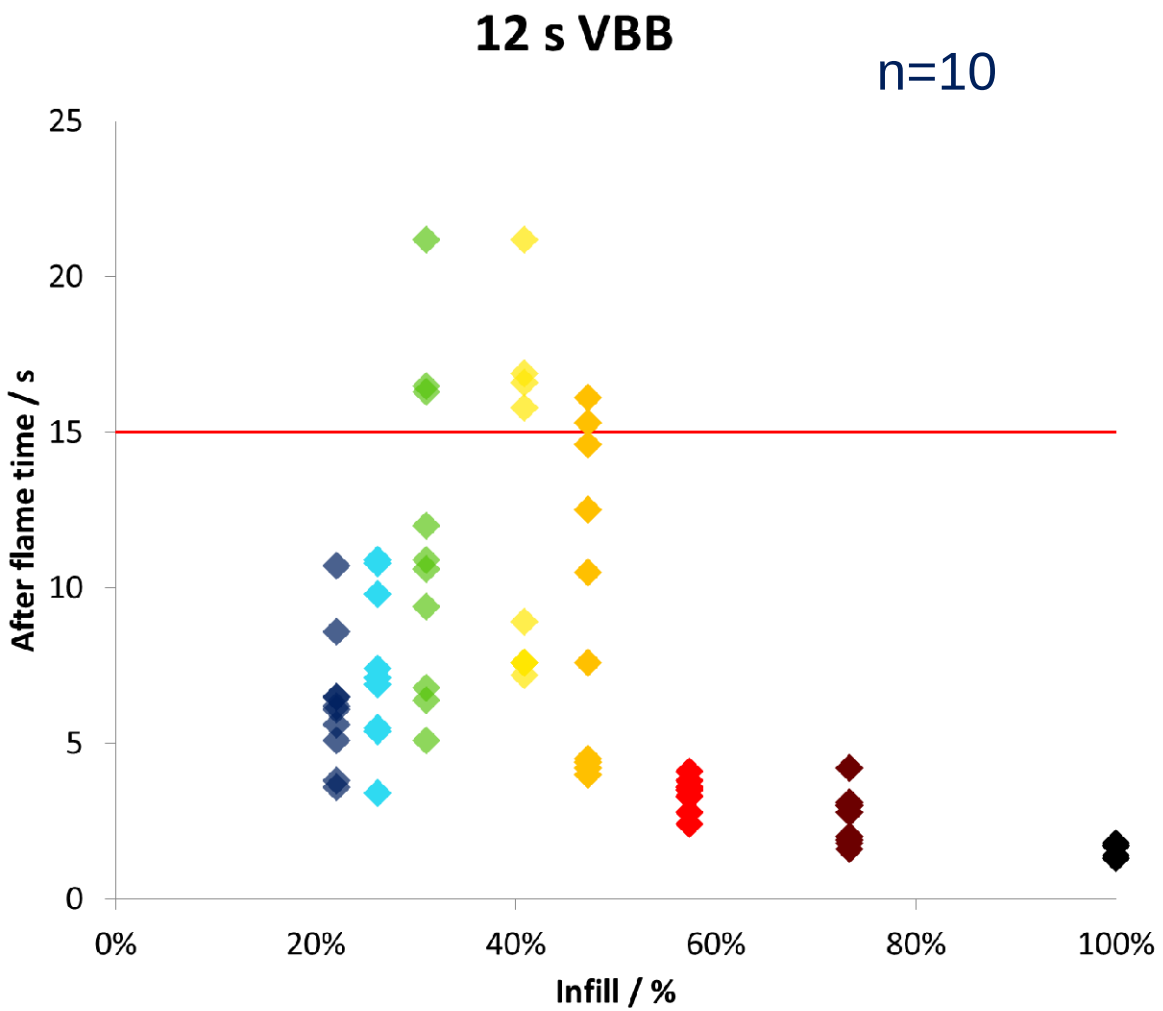
Results: XY ±45°, variation of infill





→ Lower infill = higher burn length and after flame

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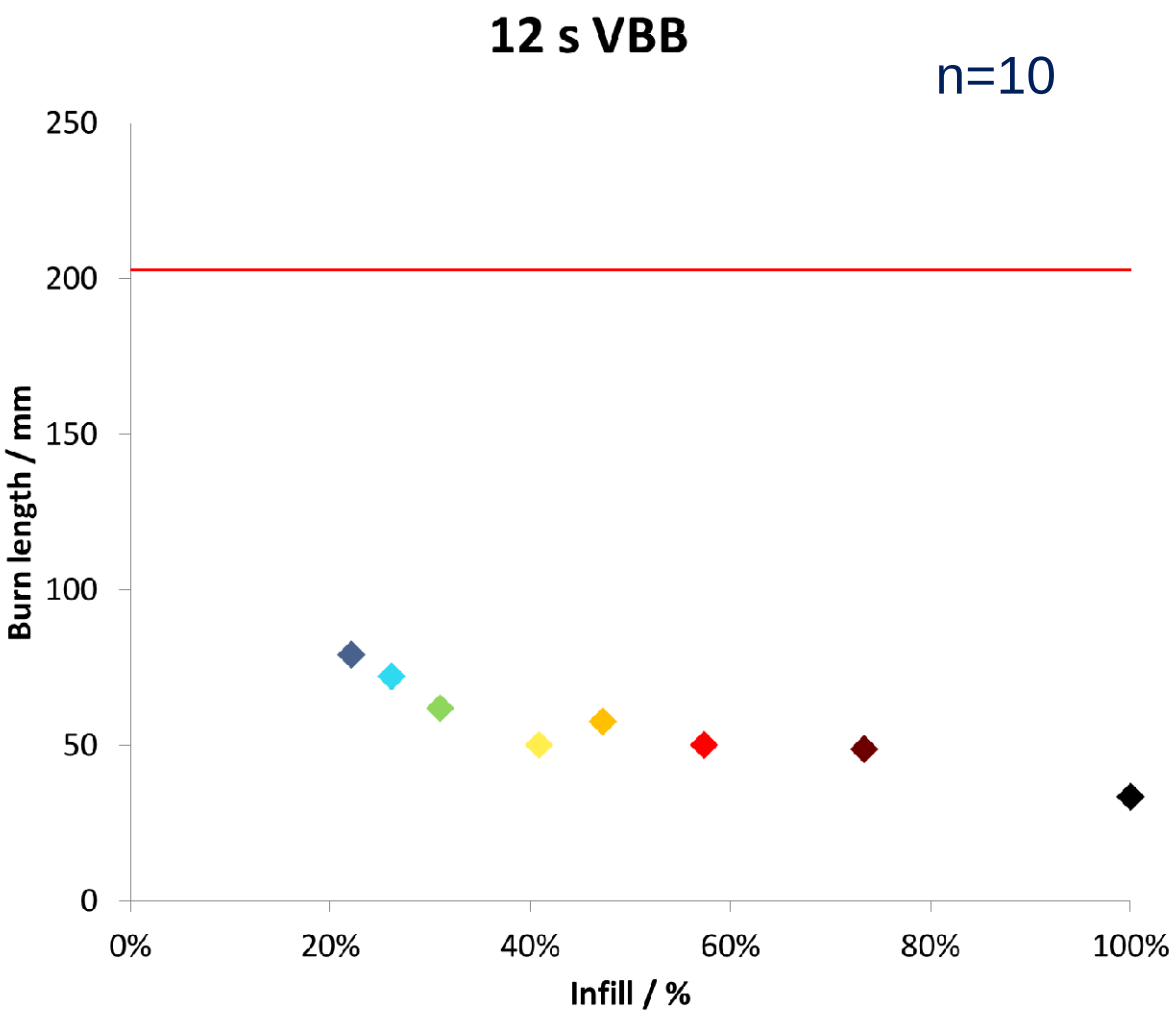
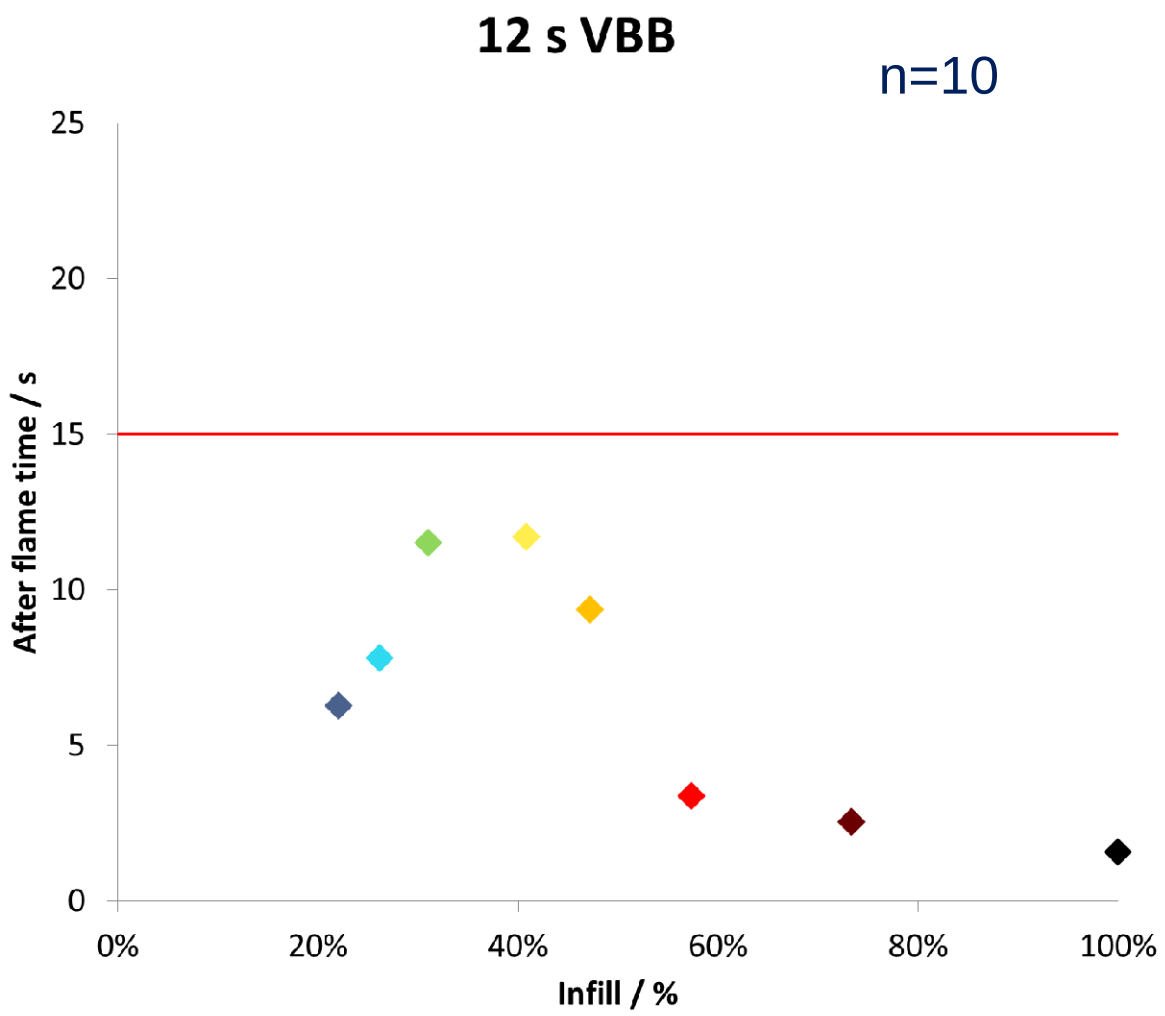
Results: XY ±45°, variation of infill





→ Lower infill = higher burn length, after flame peak around 40 %

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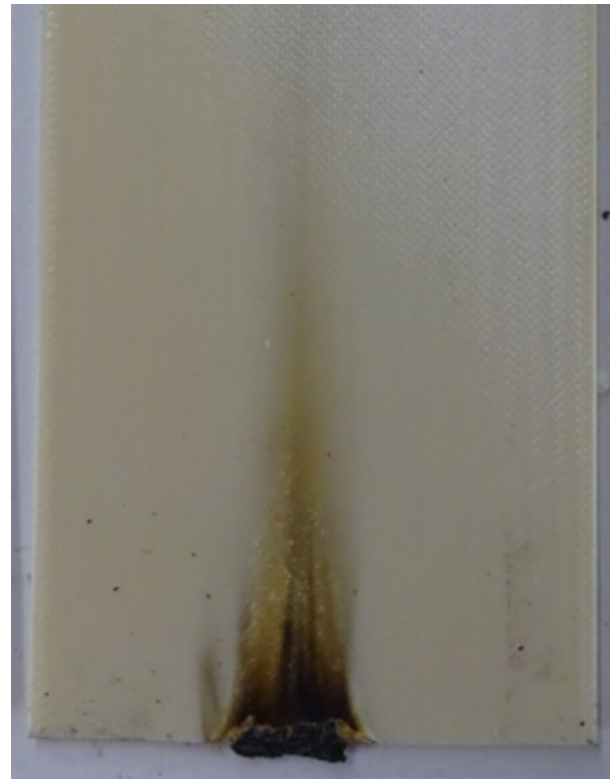
Results: XY ±45°, variation of infill

12 s VBB

100 mm

22%

41%



100%

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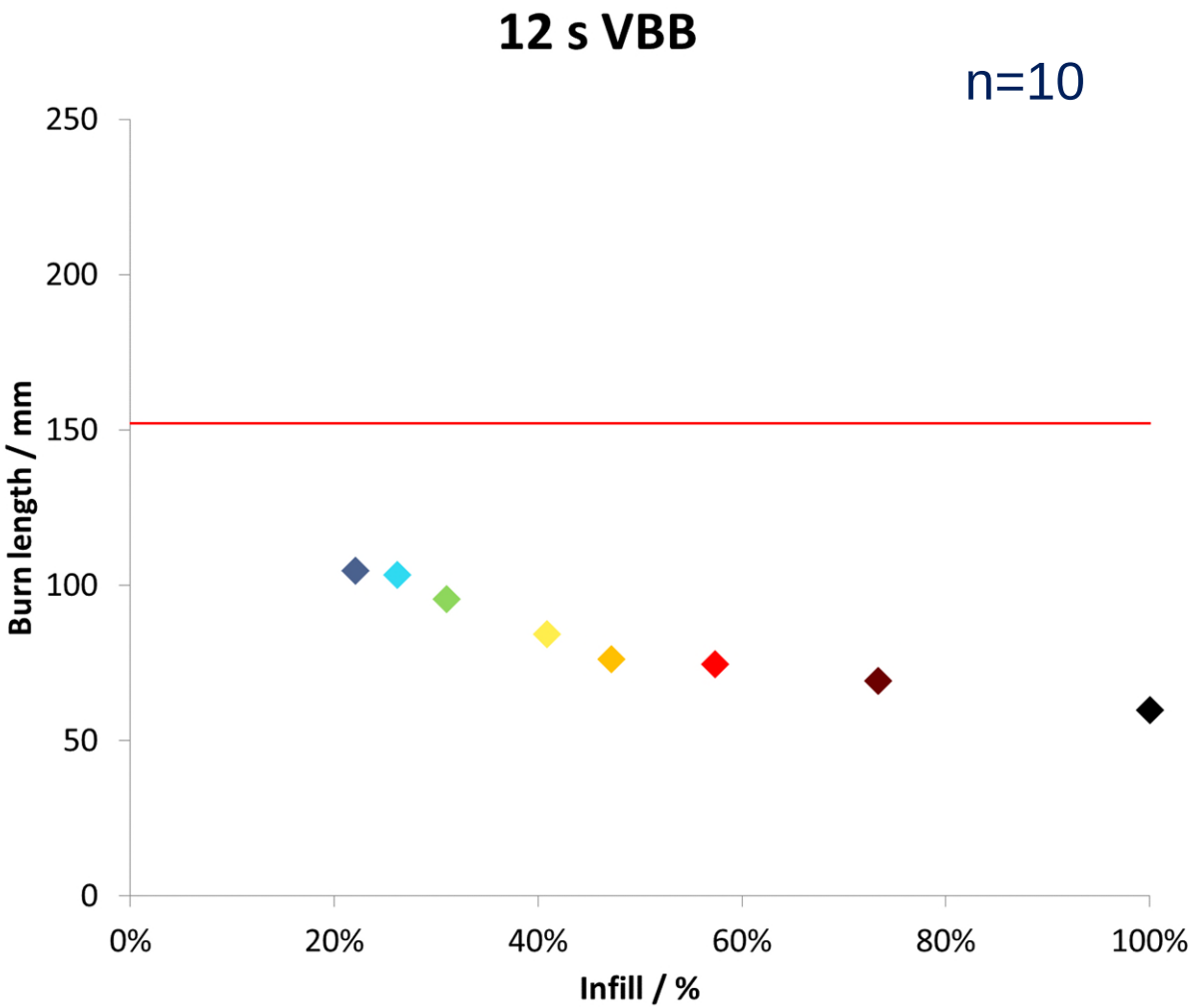
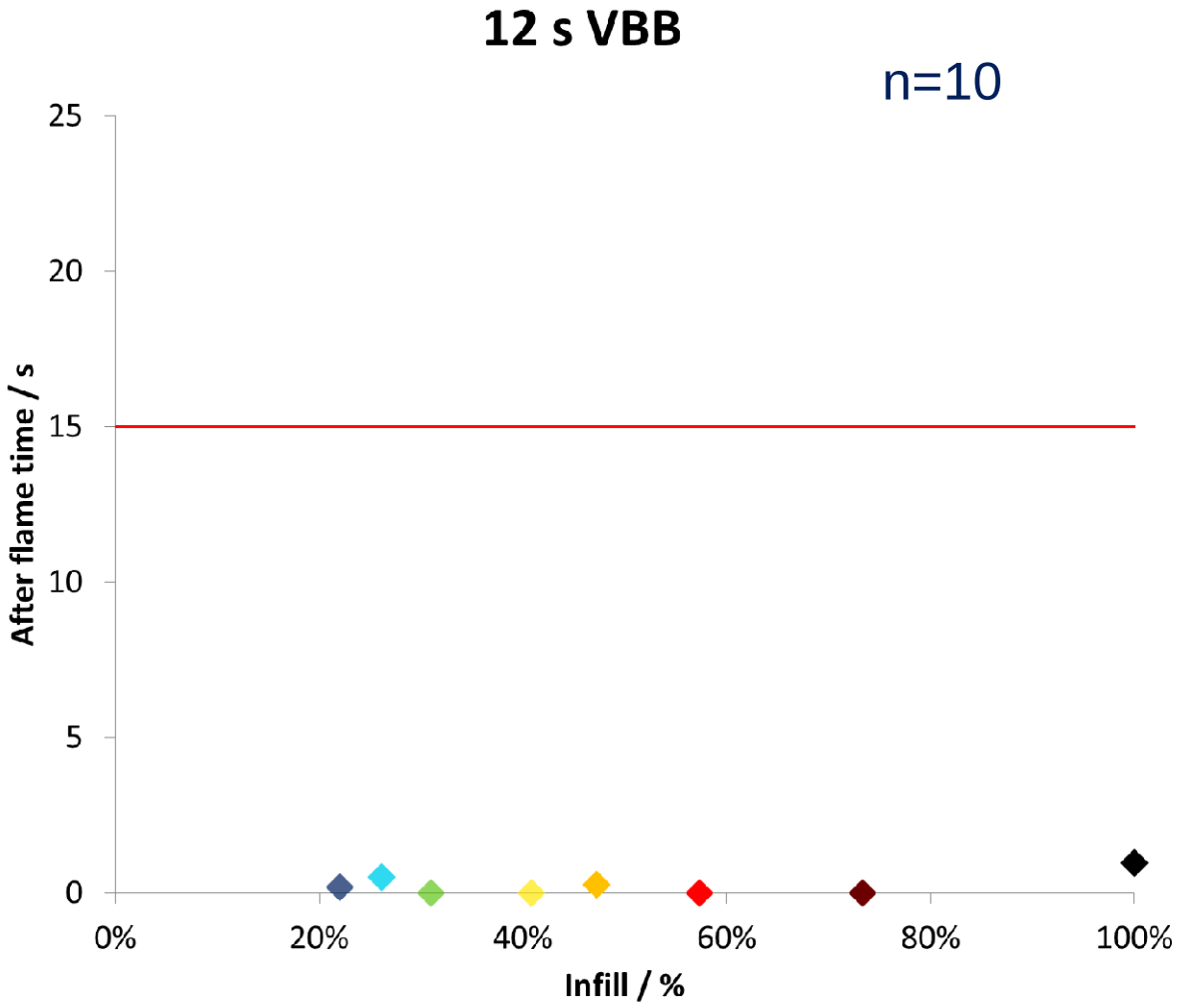
Results: XY ±45°, variation of infill





→ Lower infill = higher burn length

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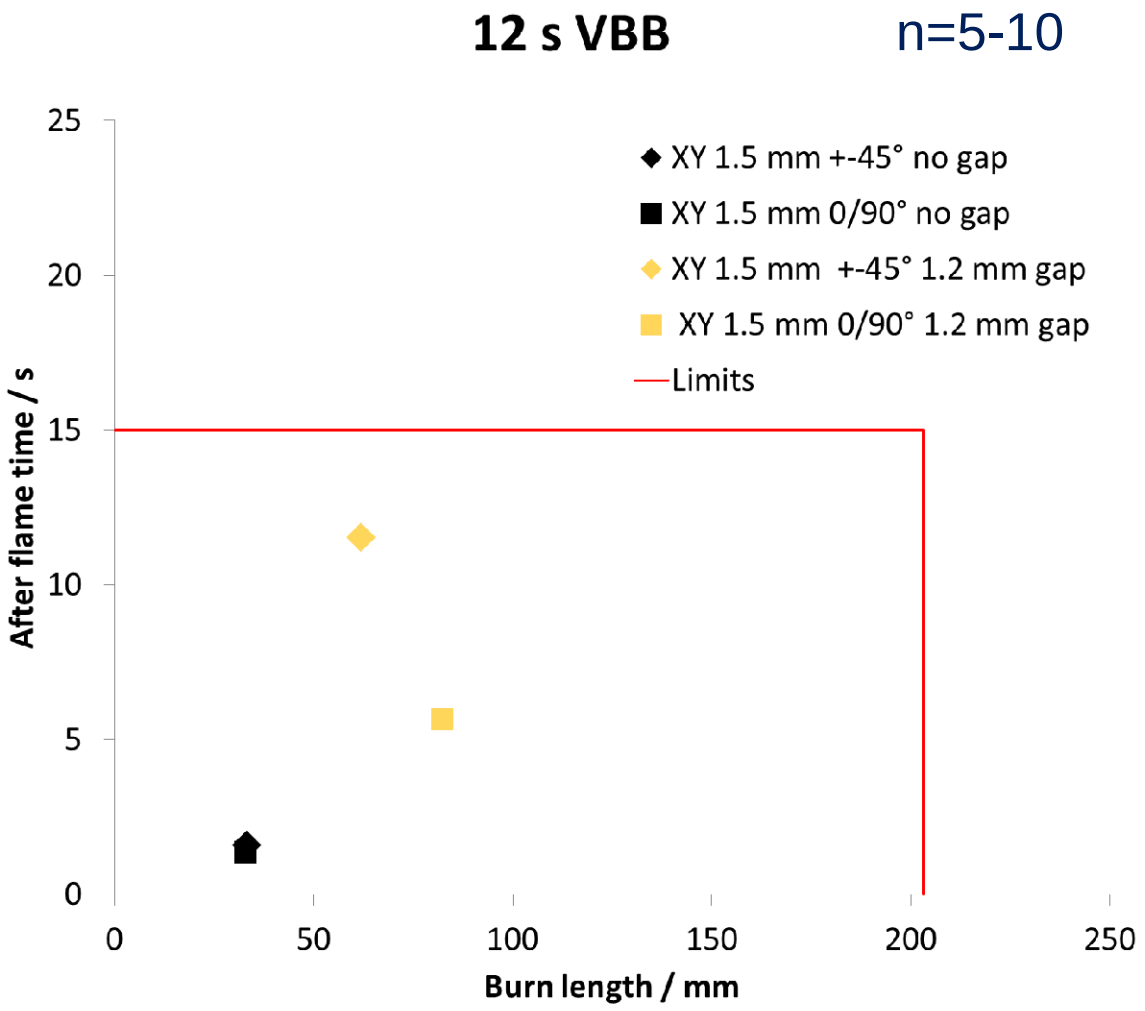
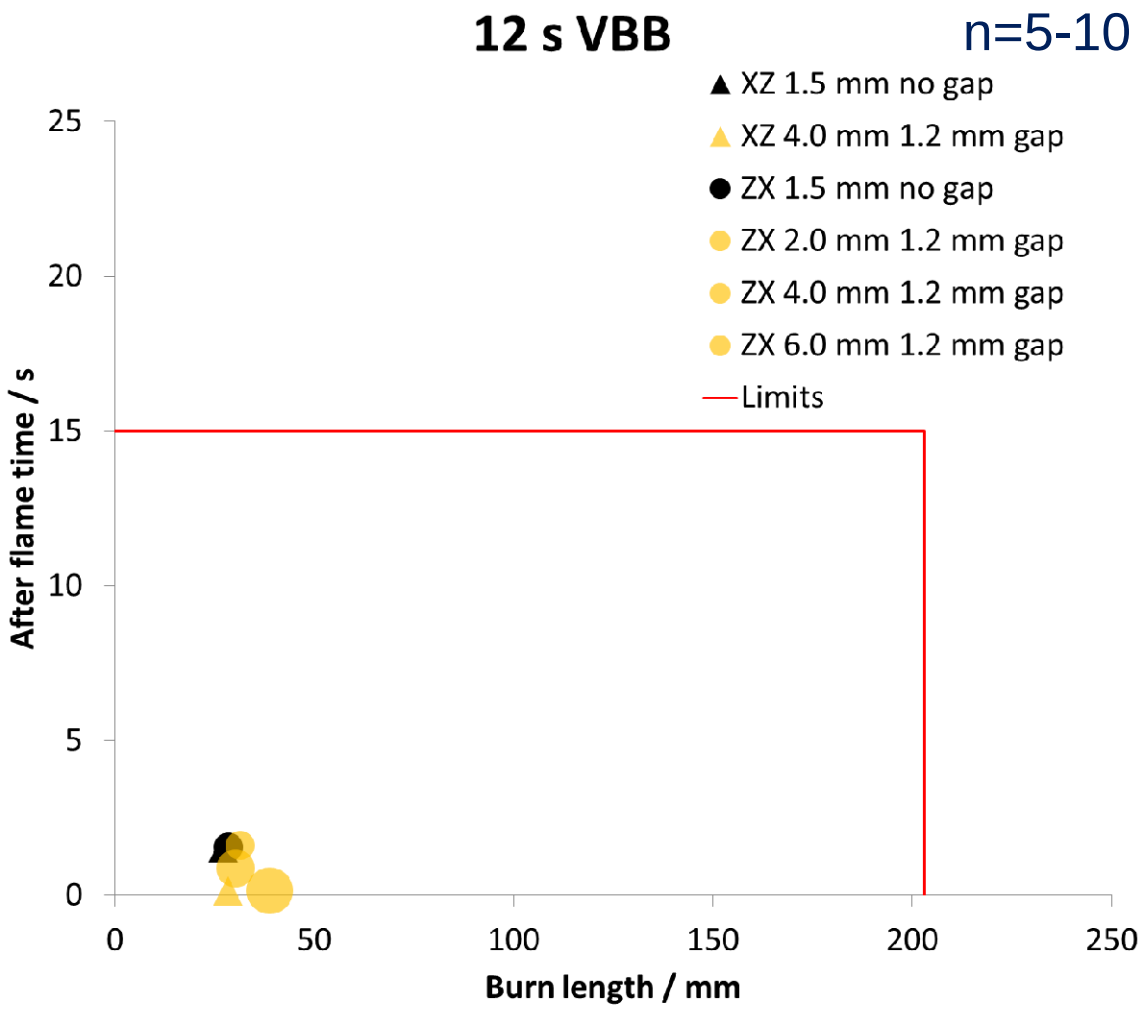
Results: variation of infill for different orientations





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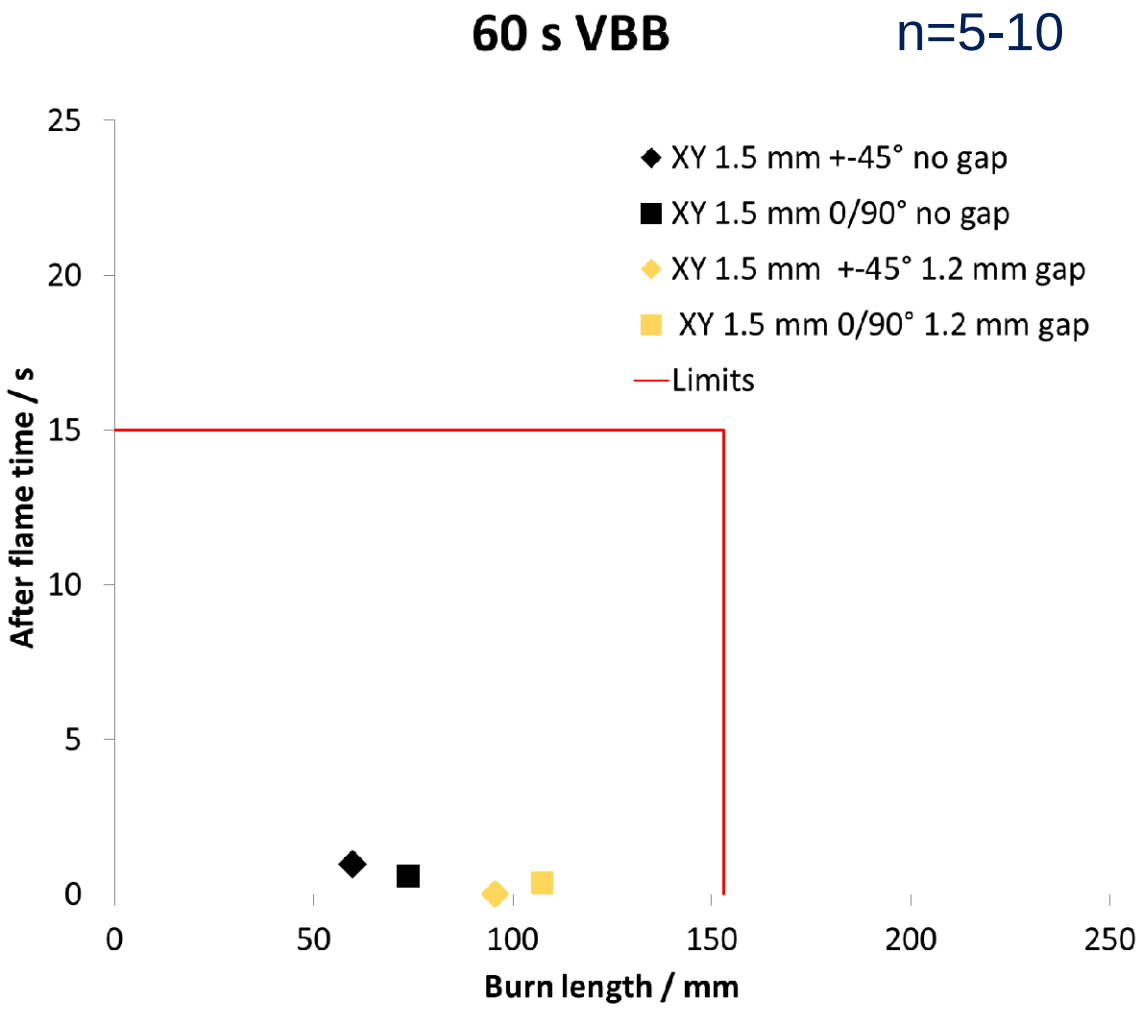

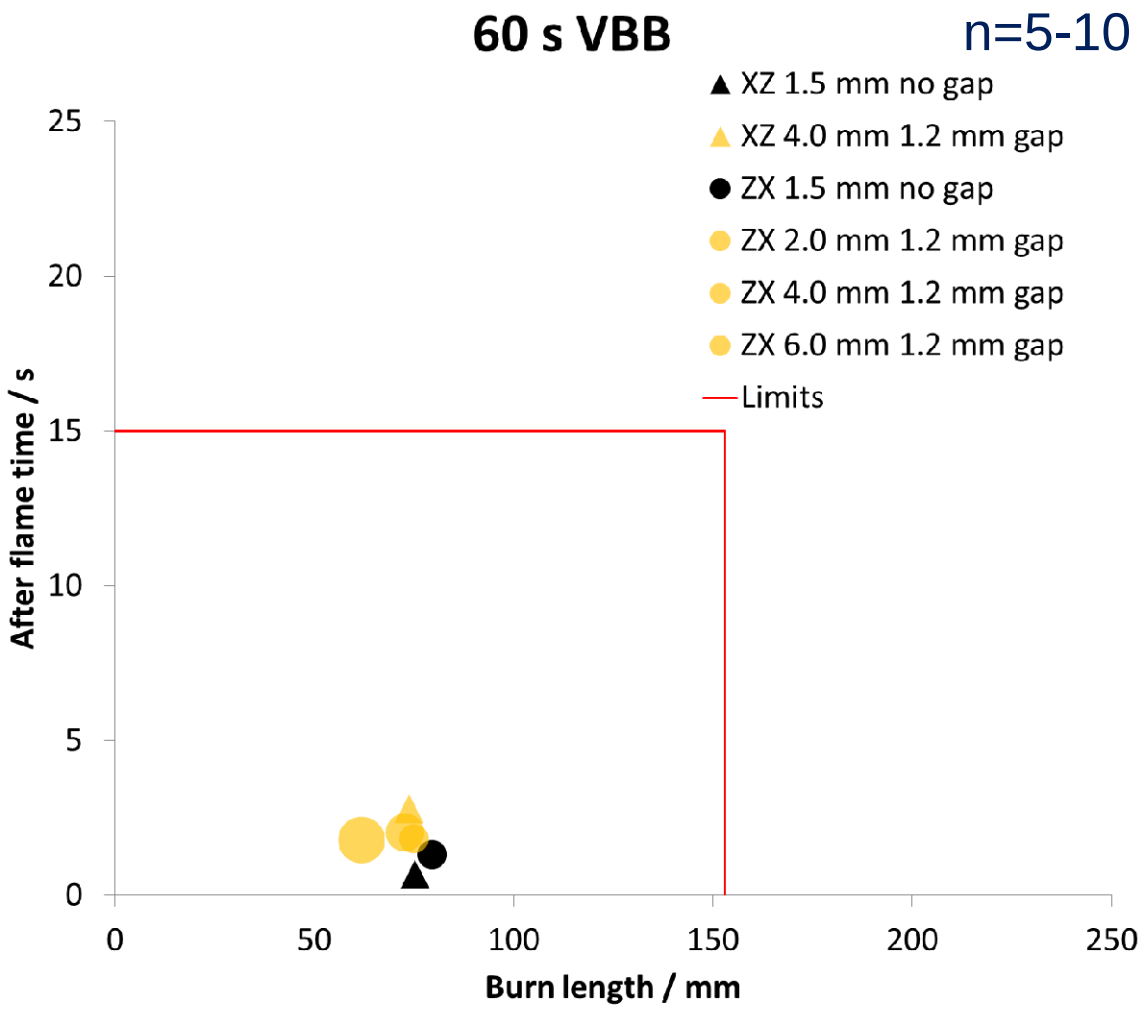

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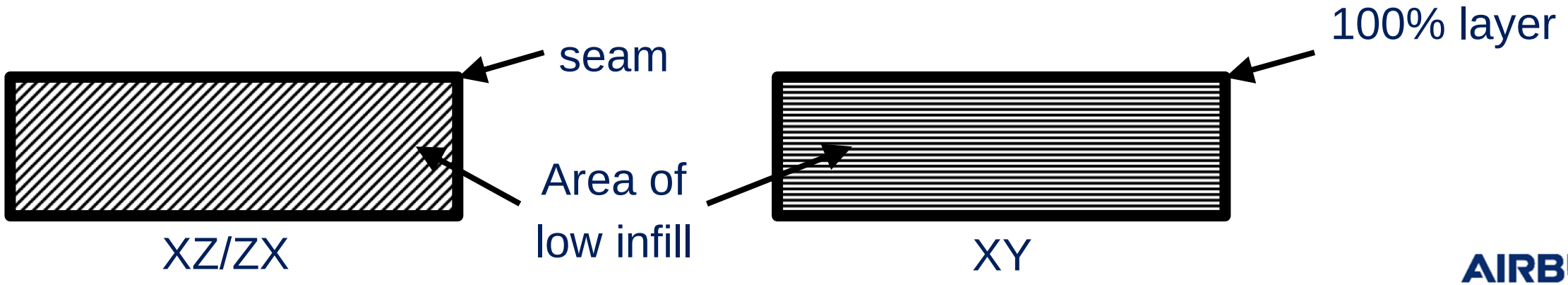
Discussion: Infill

- The pilot flame needs to warm up less material to the point of melting and gasification + air is present from all sides→ combustion front can move quicker → higher burn length
- An after flame can stay lid longer due to the same reason. Cool down is prolonged, keeping the reaction intact for a longer time.

Discussion: orientation

- Densest packing leaves no room for particularities
- For lower infill, two types can be distinguished:

1. Inside XY plane, behaviour is similar
2. XZ and ZX resemble XY sandwich coupons in the cross section, hence results are similar



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Discussion: DoE

- The number of different factors and their dependence or independence could be used in a DoE

→ Expand data base for other materials printed via FDM

Infill	Gap size	Orientation	Thickness	Sandwich	Burn length	After flame
100%	0	XY ±45°	1.5 mm	No		
⋮	1.2 mm	XY, 0/90°	2.0 mm	Yes		
⋮		XZ	4.0 mm			
⋮		ZX	6.0 mm			
22%						

Next steps

- Comparison to ULTEM 9085 from conventionl productions routes
- Comparison to ULTEM 1010 produced via FDM
- Check material change during processing steps: raw → filament on spool → printed filament

Thank you

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