Development of Sustainable PPE for Higher Threat Clearance Operations by Humanitarian Organisations

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Project Background

- In 2020, the Halo Trust reported that 59 countries and territories were still contaminated by landmines and other UXO.
- There is now a need to create sustainable armour, whilst still offering increased protection against higher velocity fragmentation.
- Natural fibres have the potential to improve the performance of hard and multi-layered armour systems whilst also reducing environmental damage and cost.

Overall Research Project Objectives

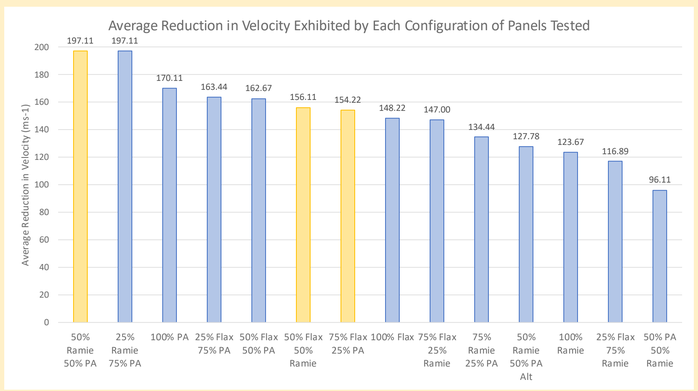
1. Understand the level of protection attributed to current vests.
2. Define survivability and determine the current most common threats and highest potential threats.
3. Define sustainability and determine how it can be applied to the production of armour solutions.
4. **Identify and test alternative hard armours against higher velocity fragmentation threats.**

Creating the Ultimate Sustainable Hard Armour Panels

- **Aim:** This project aims to create hard armour panels which are as sustainable as possible, and that offer a high level of protection when used in collaboration with the current soft armour solution.
- Initial material and ballistic testing was completed on several different panel configurations, three were taken forward for further testing.

Panel Facts and Figures

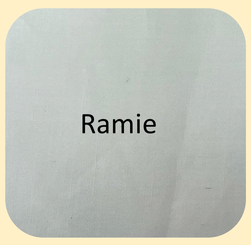
Material	Layers	Av dV (ms-1)	Weight (g)	Thickness (mm)	Cost per Panel (£)
50% Ramie 50% PA	20 10	197.11	162.22	7.19	13.54
50% Flax 50% Ramie	8 20	156.11	192.83	8.34	11.06
75% Flax 25% PA	12 5	154.22	189.82	9.23	8.02



Graph showing the ballistic performance of the different panel configurations tested

Materials Used

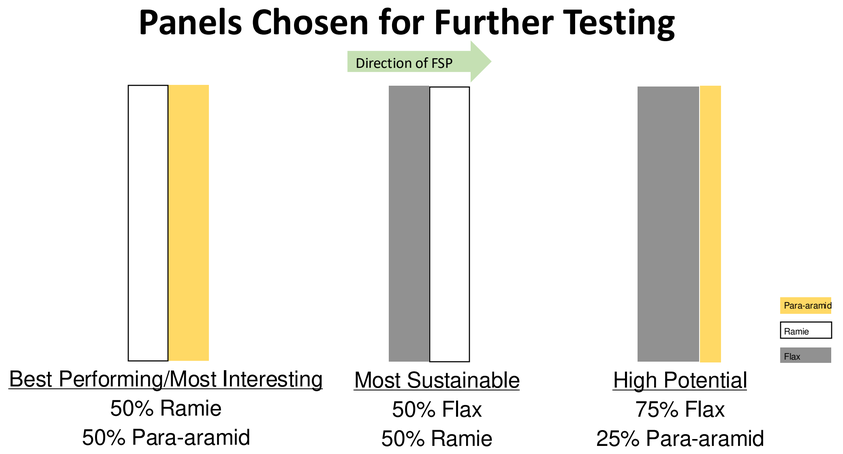
Satin Weave
Area Density - 172.59gm^{-2}
Man-made Fabric



Lightweight Woven Fabric
Area Density - 87.13gm^{-2}
Natural Fabric

2/2 Twill Weave
Area Density - 215.58gm^{-2}
Natural Fabric

Panels Chosen for Further Testing



Best Performing/Most Interesting
50% Ramie
50% Para-aramid

Most Sustainable
50% Flax
50% Ramie

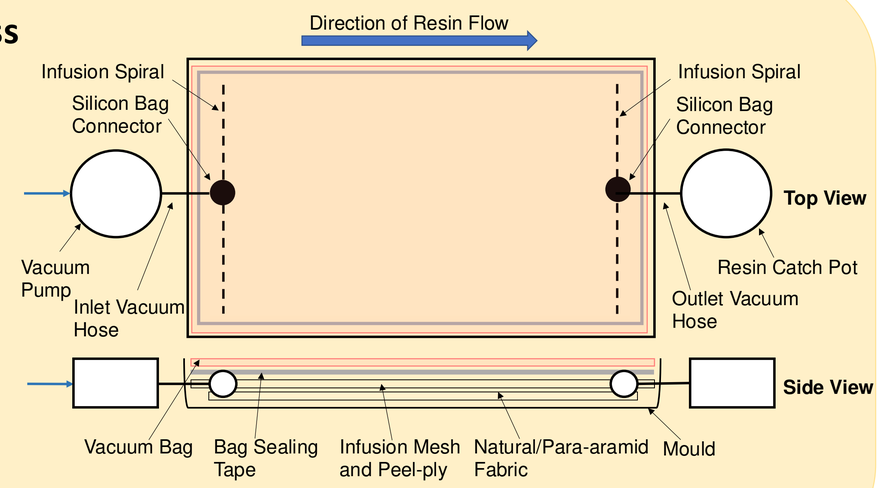
High Potential
75% Flax
25% Para-aramid

Manufacturing Cost Break Down

Item	Cost/Unit (£)
Para-aramid Fabric	21.00/sqm
Flax Fabric	11.36/sqm
Ramie Fabric	14.65/sqm
Vacuum Infusion Starter Kit	145.00 each
Vacuum Pump	242.50 each
Peel-Ply (Consumable)	1.81/sqm
Infusion Mesh (Consumable)	2.29/sqm
Vacuum Bag (Consumable)	1.63/sqm
Vacuum Tape (Consumable)	0.37/m
Resin (Consumable)	15.95/kg
Resin Spiral (Consumable)	0.35/m
Connection Pipe (Consumable)	0.50/m

Manufacturing Process

- Panels were fabricated via Resin Infusion using an Easy Composites Kit.
- Easy to set up and use in any environment – no need for specialised training.
- Some consumables single use and therefore a continued cost and environmental concern.



Schematic showing the production of a fabric epoxy resin composite hard armour panel via the process of resin infusion. Illustration created by the author.

Sustainability Considerations

Economic

- Commercially available hard armour of a similar rating ~ £175
- Natural fabrics are cheaper than para-aramids.

Environment

- Natural fibres are more environmentally friendly than para-aramids.
- Natural fabrics are easily accessible and are cleaner to produce.

Social

- Producing the fabric and panels can provide jobs in local communities.

End of Life

- Current armour solutions cannot be recycled and are stored at EoL.
- Panels made of natural fibres may be broken down and recycled.

Next Steps

- Test the three chosen panels at an increased velocity (450ms^{-1}) on the single stage gas gun.
- Investigate methods of breaking down panels post testing to assess whether they can be fully recycled at the end-of-life stage.
- Investigate the possibility of using bio-resins or other natural alternatives during the manufacturing process.

References

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