TWENTY-THIRD INTERNATIONAL CONFERENCE ON COMPOSITE MATERIALS (ICCM23)

ULTRASONIC WELDING OF CF/PEKK TO CF/EPOXY THROUGH OPTIMISATION USING MACHINE LEARNING

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Presentation Outline

- Motivation
- Introduction
- Manufacturing
- Ultrasonic welding
- Artificial Neural Network
- Validation
- Conclusion

Motivation

- The ability of thermoplastic materials to be re-melted allows for fusion joining technique to be used.

- Currently, all primary structures are made of thermoset materials.

- Reduce material wastage and experimental tests.

Objective

- To optimise the joining of dissimilar materials using ANN.

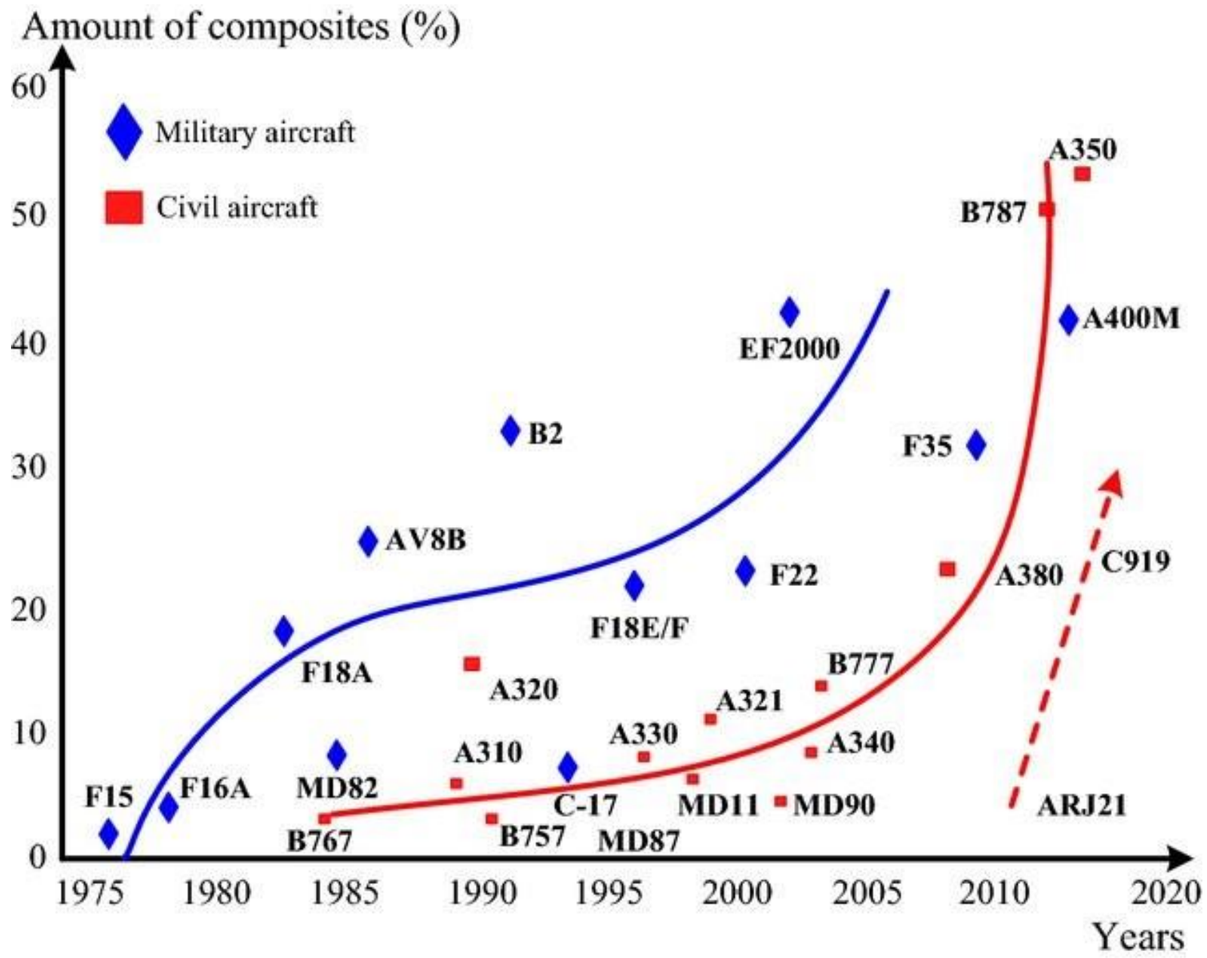
Introduction

- Relative to thermoset composites, thermoplastic composites are tougher.

- They can be moulded, melted, and remoulded without altering its physical properties making it recyclable and open to fusion joining techniques.

- Fusion joining techniques are of three types: electromagnetic welding, friction welding and thermal welding.

- Ultrasonic welding process is an effective joining process.

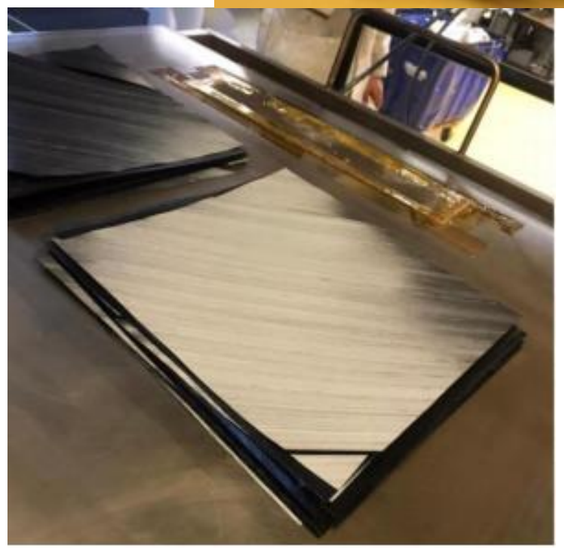


Manufacturing

- The laminates were manufactured in the autoclave.

- A PEI film was co-cured in the epoxy prepreg

Parameters	HexPly 8552	HTS45/PEEK
Supplier	Hexcel	Teijin
Fibre Volume	60	60
Processing Temperature (° C)	180	375
Processing Pressure (bars)	6.5	6.5
Processing Time (hours)	2	2
Stacking sequence	$[-45/0/45/90]_S$	$[0]_8$
Ply thickness	0.13 mm	0.18 mm

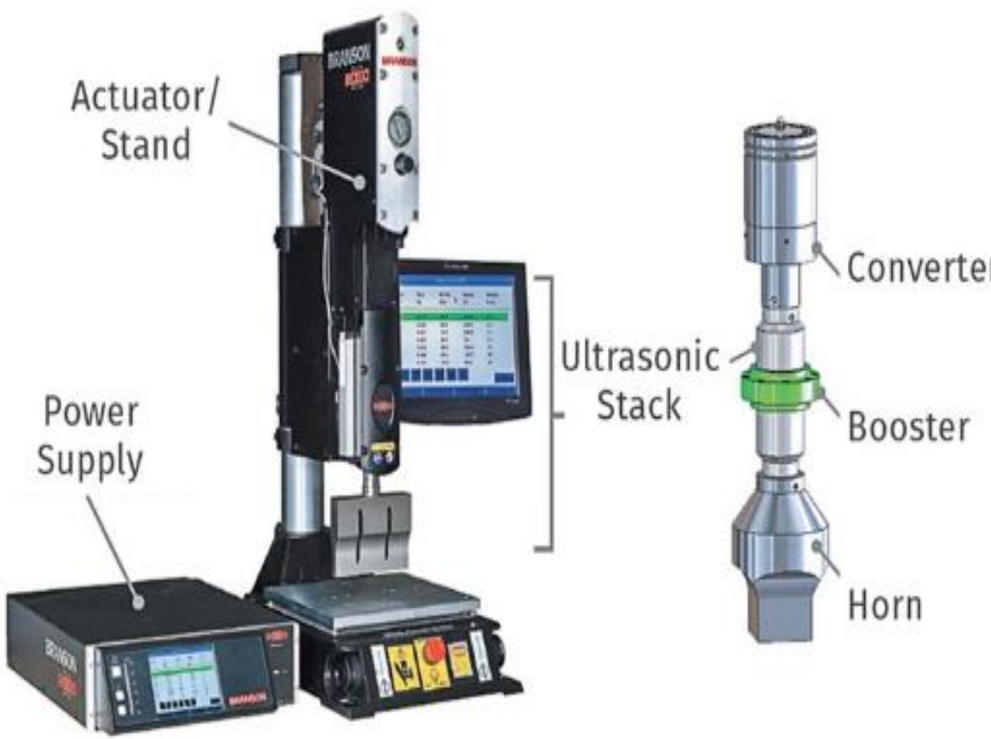


Ultrasonic Welding

- Ultrasonic Welding falls under the frictional welding category

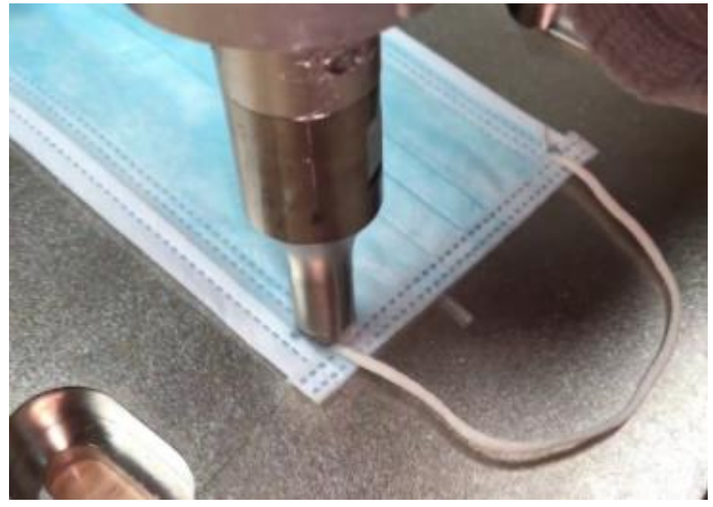
- Low frequency and high amplitude are applied transversally to the parts to be welded

Advantages	Limitations
Very short welding times	Studies only limited to overlap and shear joints
No foreign material required	Currently thickness of adherend is limited to 3 mm
They can be automated	Very dependent on the material properties
Avoids surface preparation	Is restricted by the power of the machine



Ultrasonic Welding

- They are used in the medical industry for various products as they are contamination free.



- They are used in the packaging and electronic industry.

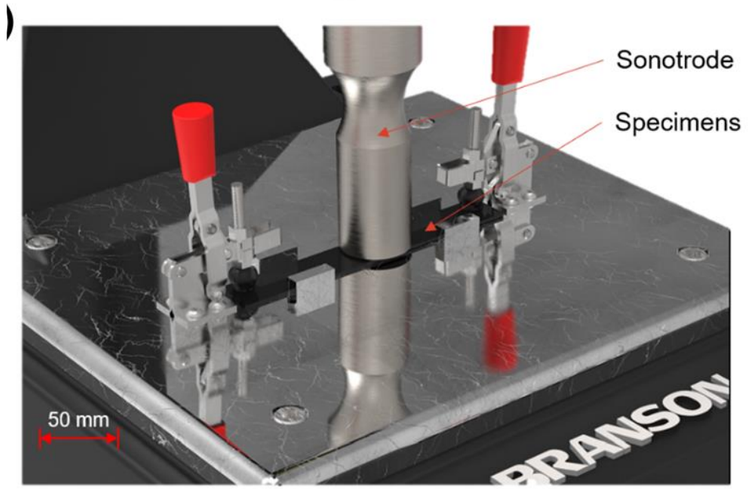
- They are currently used in the aerospace industry by Lockheed-Georgia to weld thermoplastic/graphite tape material for C-130 Hercules aircraft.

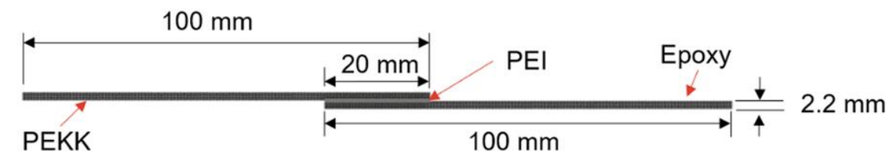
- Generating interest in the transportation industry

Training of the model

- A hybrid genetic algorithm – artificial neural network (GA-ANN) model was developed.
- Input parameters were welding energy, vibration amplitude, and welding force to the corresponding Lap Shear Strength.
- A 3^3 DOE was performed with 3 repeats.

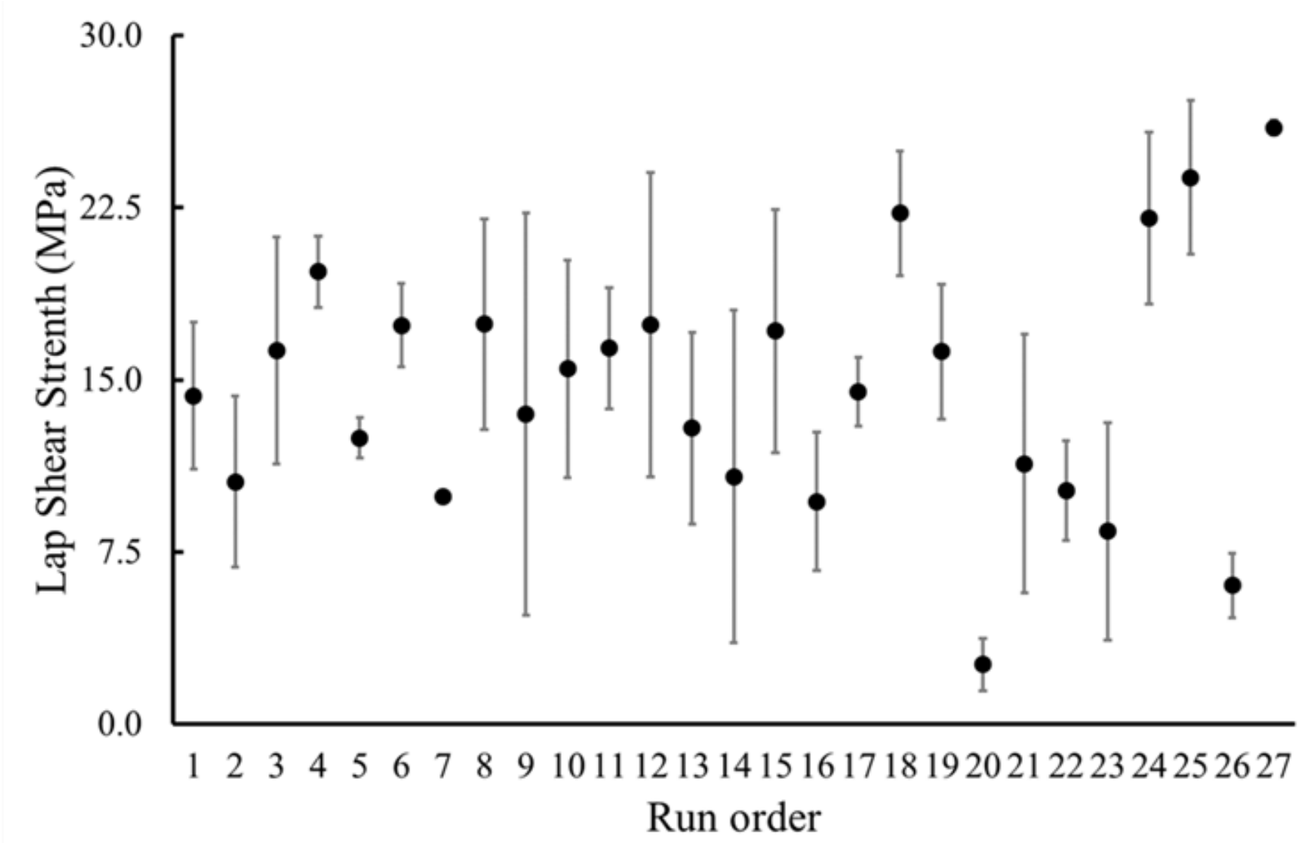
Input parameters	Minimum	Median	Maximum
Welding energy (kJ)	1	1.75	2.5
Welding force (N)	400	800	1200
Vibration amplitude (µm)	85	100	115





Experimental testing

- 81 tests were performed.
- Parameters of run 27: 1750 J, 1200 N and 100 µm resulted in the highest LSS.
- Parameters of run 20: 1750 J, 1200 N and 100 µm resulted in the lowest LSS.



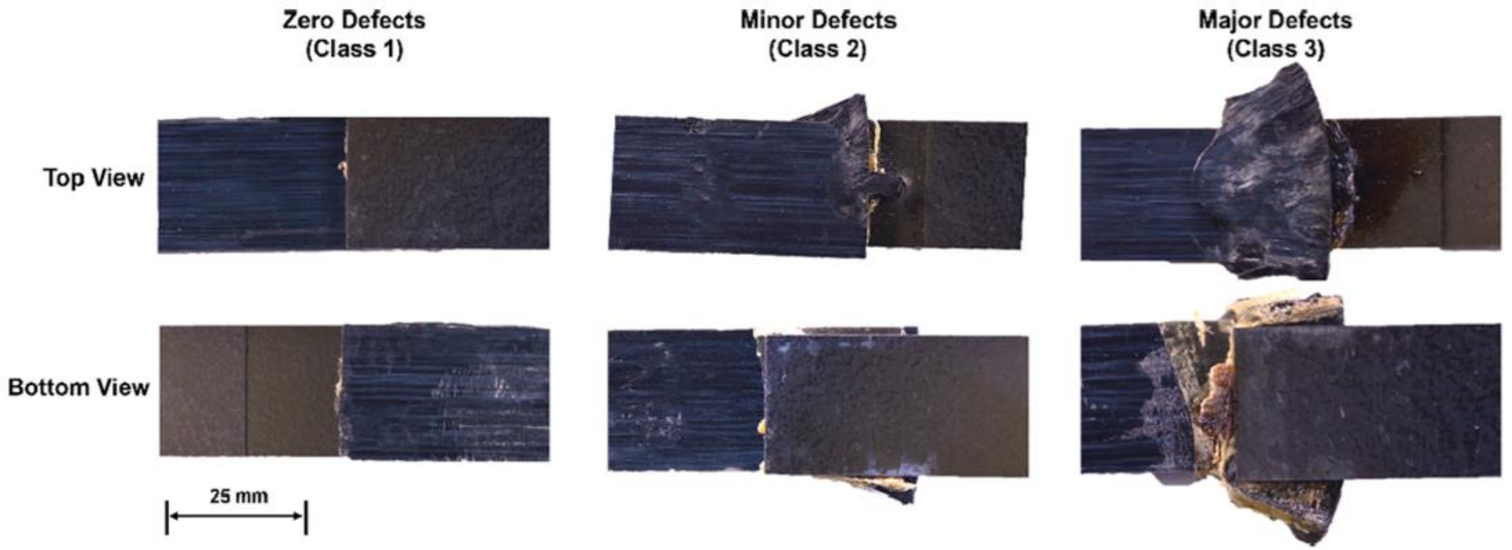
Experimental testing

- The joint specimens were divided into three visual categories.

- Zero defects where there was no visual defect visible to the naked eye or the joint was very weak.

- Minor defects where there was PEI or resin squeeze and some indentation of the sonotrode.

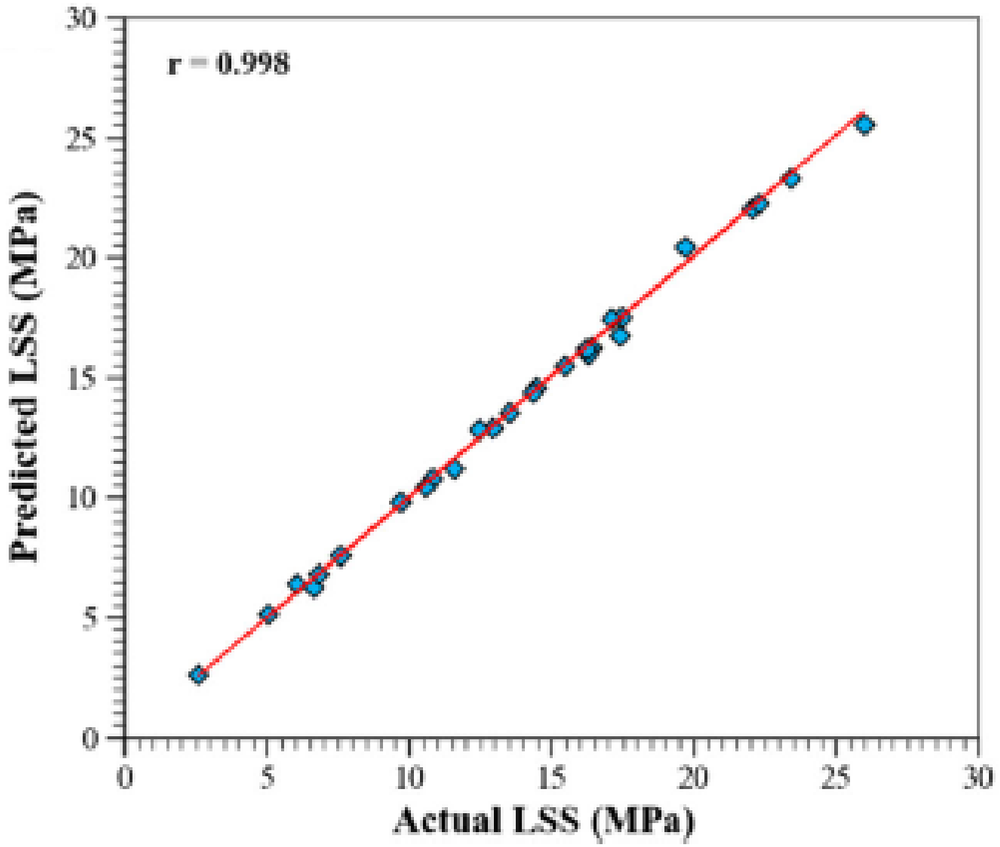
- Major defects where there was complete fibre pushout or degradation.

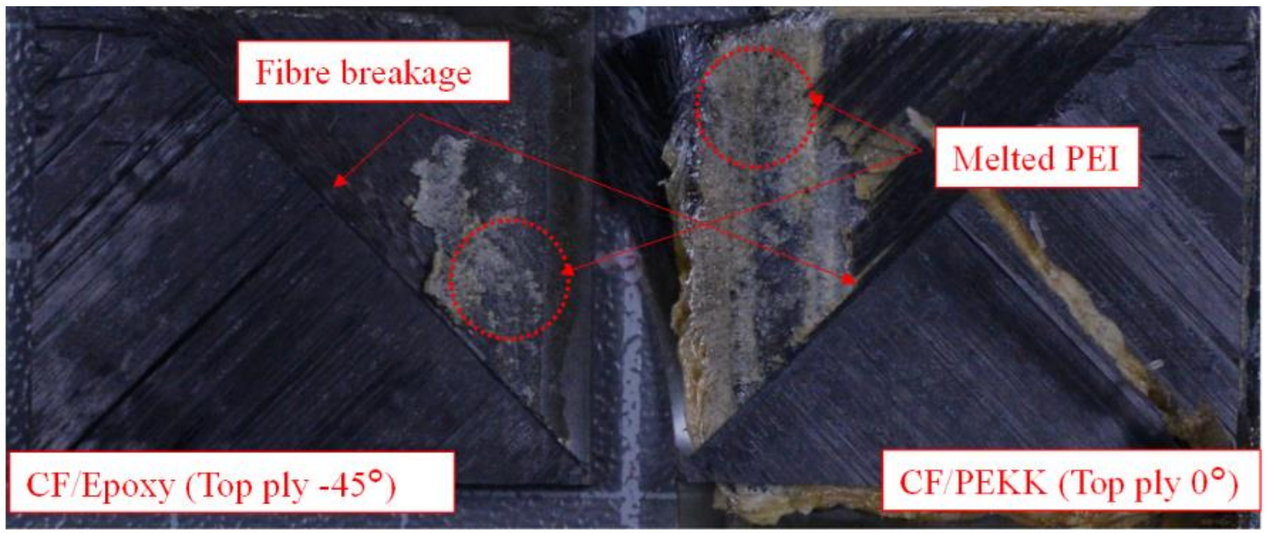


Validation

- Optimised parameters provided by ANN: 1263 J, 842 N and 106 µm

- Predicted LSS of 25.3 MPa vs Experimental LSS of 24.5 MPa





Conclusion

- A GA-ANN model was created to predict the weld strength and provide the optimised process parameters for the ultrasonic welding.
- The GA-ANN model predicted with an accuracy of 97%.
- The fracture surface of CF/Epoxy to CF/PEKK showed a strong adhesion between the adherends.
- The model development approach is relevant to the optimisation of any manufacturing process.

Thank you

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