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INFLUENCE OF STRAIN RATE AND TYPE OF MATRIX ON MECHANICAL PROPERTIES OF CARBON THERMOPLASTIC LAMINATES UNDER DYNAMIC COMPRESSION PRODUCE WITH LATP/LAFP

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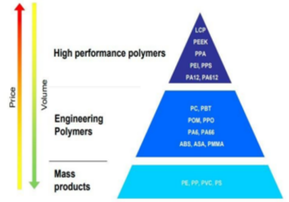
Abstract

Thermoplastic composite materials are used for heavier-duty applications like aerospace, space and medical industries. Thermoplastics composite materials systems are generally considered as substitutes for thermoset materials defense applications to take advantage of fabrication cost reductions afforded by consolidating without an autoclave. Production of composites from carbon thermoplastic tapes with different matrices PEEK, PPS, PEKK using LATP/LAFP consists of consists of three main steps: impregnation, consolidation and crystallinity. Impregnation is a parameter that cannot be controlled by automatic fiber/tape laying while consolidation and crystallinity can be controlled. Consolidation consists of two sub-processes: intimate contact and autohesion. To achieve better final characteristics of the thermoplastic composite it is necessary to achieve a good degree of intimate contact and good self-connection.
The carbon fibre volume fraction is 60% in the CF/PPS laminate/ CF/PEEK laminate and CF/PEKK laminate. After a good selection of technological processes, the composite laminates were manufactured using LAFP (in-situ Laser assisted fibre placement technology according to quasi-isotropic lay-up sequence: [0/45/-45/90]2s. Then the composite laminates were cut into a cube specimen by a diamond saw, and the size of 10 mm (length) x 10 mm (width) x 4.5mm (thickness) for high-strain-rate compression tests. To avoid the size effects in the impact tests, the specimens in all tests had the same dimension.
In this paper, we investigated the dynamic compressive behaviour of thermoplastic polymer composites in the in-plane and out-of-plane directions over a different matrix (PPS, PEEK, PEKK) and strain rates (0.001; 0,1; 10; 800; 1800/s) and with a Split Hopkinson Pressure Bar (SHPB) apparatus.
The dynamic stress-strain behaviours and mechanical properties were analysed. The dynamic failure mechanisms were comprehensively characterized at different strain rates and different matrix (PPS, PEEK, PEKK) in the in-plane and out-of-plane directions.

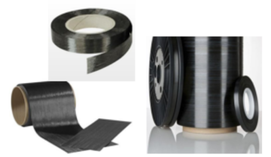
Experimental procedure

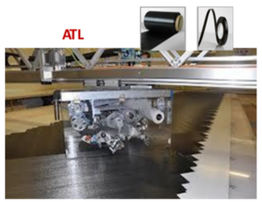
MATERIALS using for samples

Thermoplastic Matrices

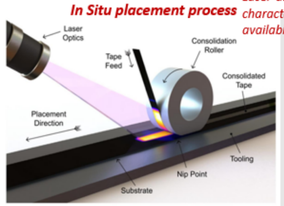


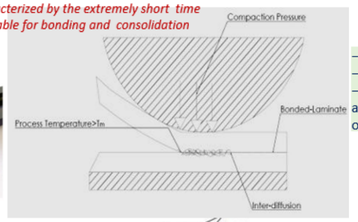
A- UD prepreg: **PEEK/AS4** carbon fibers
B- UD prepreg : **PPS/AS4** carbon fibers
C - UD prepreg : **PEKK/AS4** carbon fibers





In Situ placement process *Laser-assisted tape placement process is characterized by the extremely short time available for bonding and consolidation*

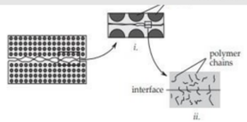




- new production technologies,
- are still being researched and improved,
- promising technology for fabrication of advance, aerostructures and structures for automotive and other industries.

- potential for in situ consolidation
- flexible and automated production
- high productivity and
- low energy consumption

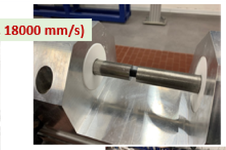
i. intimate contact has to be achieved between the two layers and
ii. intermolecular diffusion, a process which is also known as healing, takes place between the surfaces in intimate contact

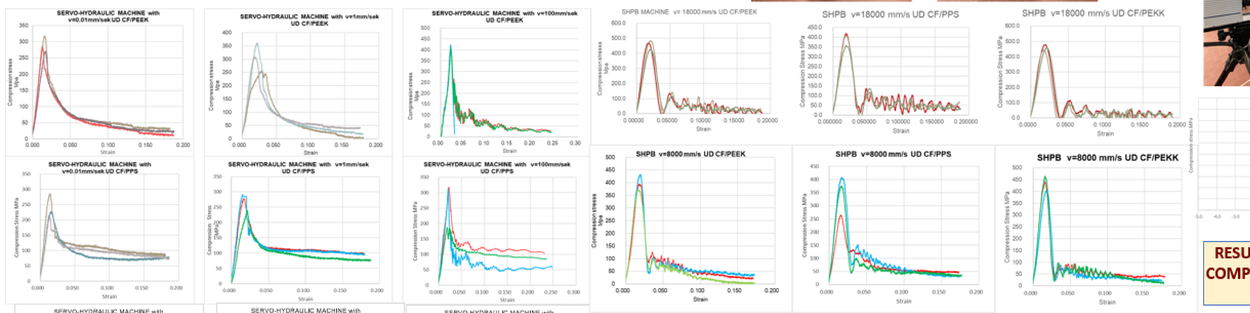


Results and discussion

SERVO-HYDRAULIC MACHINE FOR TESTs (V 0.01, 1, 100 mm/s)

SHPB MACHINE FOR TESTs (V 8000, 18000 mm/s)



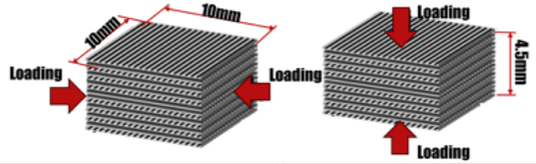


RESULTS FOR DYNAMIC COMPRESSIVE STRENGTS, MPA

reinforcement	Strainrate (s)	V (mm/s)	PEEK	PPS	PEKK	log strin rate	log V
Carbon fiber	0.001	0.01	291.5	242.2	330.2	-3.00	-2.0
Carbon fiber	0.1	1	309.4	270.2	345.4	-1.00	0.0
Carbon fiber	10	100	416.7	271.9	349	1.00	2.0
Carbon fiber	800	8000	400.2	349.4	437	2.90	3.9
Carbon fiber	1800	18000					

in the in-plane directions *out-of-plane directions*

Prepared Samples for dynamic compressive tests and condition of testing



CF/PEEK laminate			CF/PPS laminate			CF/PEKK laminate		
in the in-plane directions [0/45/-45/90]2s								
Sample No.	V(mm/s)	Strain rate (s)	Sample No.	V(mm/s)	Strain rate (s)	Sample No.	V(mm/s)	Strain rate (s)
a01, a02, a03	0.01	0.001	b01, b02, b03	0.01	0.001	c01, c02, c03	0.01	0.001
a11, a12, a13	1	0.1	b11, b12, b13	1	0.1	c11, c12, c13	1	0.1
a21, a22, a23	100	10	b21, b22, b23	100	10	c21, c22, c23	100	10
a31, a32, a33	8000	800	b31, b32, b33	8000	800	c31, c32, c33	8000	800
a41, a42, a43	18000	1800	b41, b42, b43	18000	1800	c41, c42, c43	18000	1800
out-of-plane directions [0/45/-45/90]2s – in process								