MECHANICAL AND THERMAL PROPERTIES OF FILAMENT WOUND COMPOSITE PIPES

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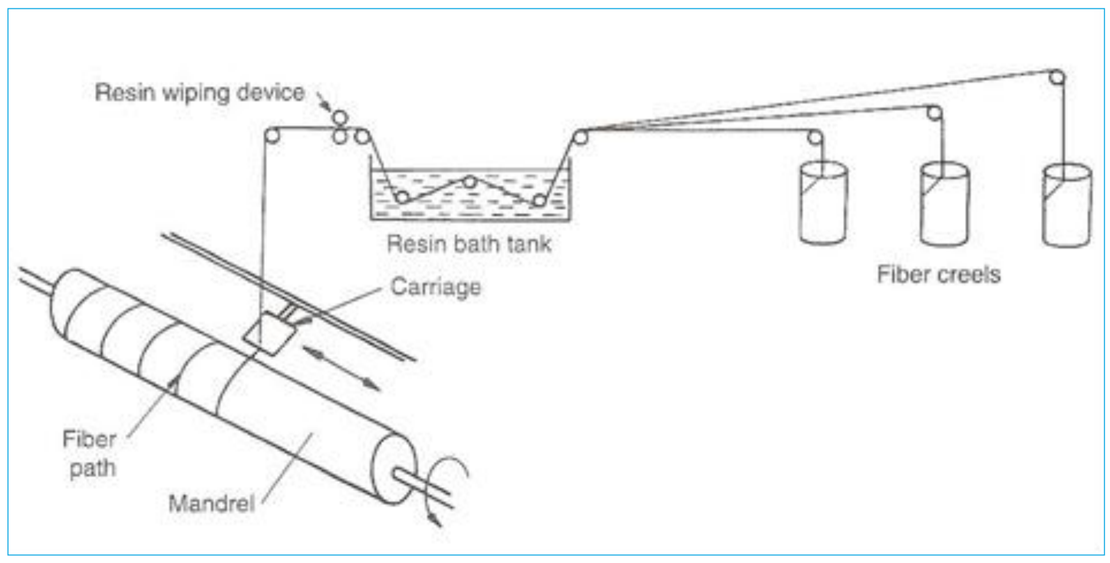
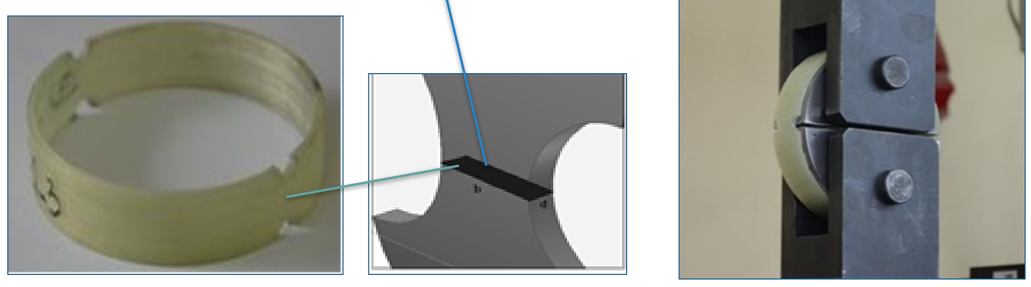
Schematic presentation of the filament winding technology



Coding convention of variables

	Winding speed, m/min	Fiber tension, N	Winding angle, ^{0}
Zero level, $x_i = 0$	13,125	47	50
Interval of variation	7,875	13	40
High level, $x_i = +1$	21	60	90
Lower level, $x_i = -1$	5,25	34	10
Code	x_1	x_2	x_3

Cross-sectional area on which hoop tensile stress is applied

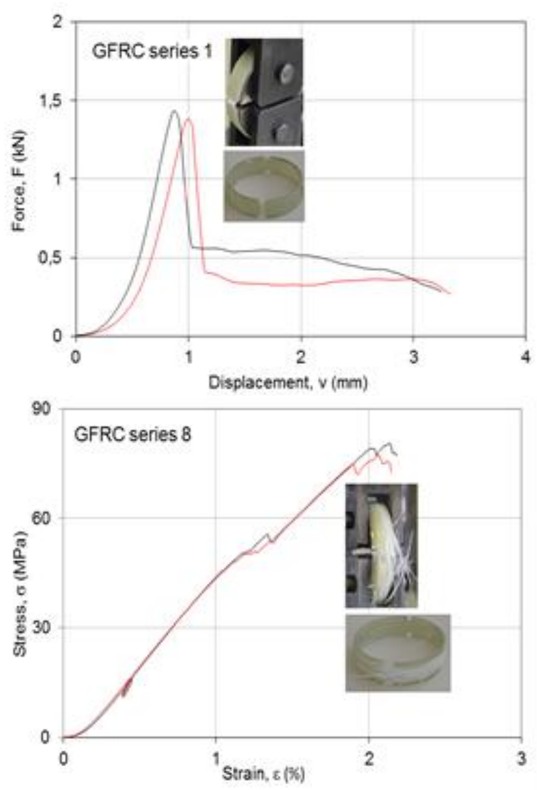


split-disk test specimen and test fixture with specimen for tensile testing

tubular test specimen and test fixure with speciment for compression testing

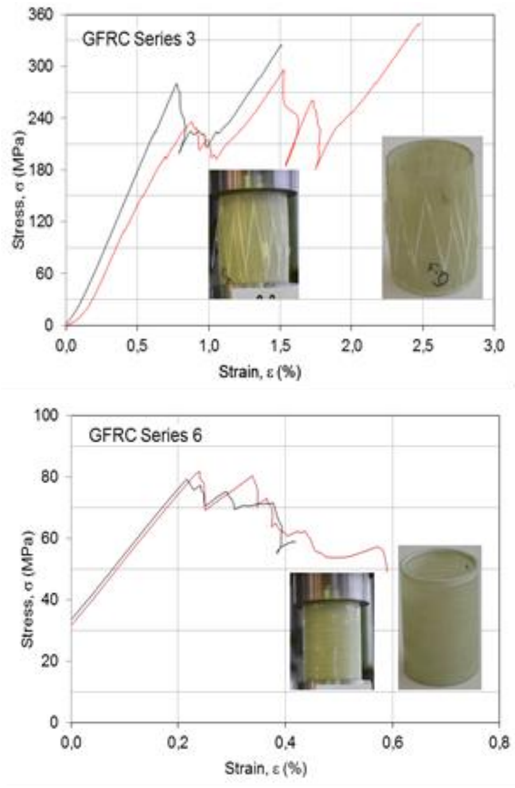
Hoop tensile strength results of split-disk tests

Hoop tensile strength results				
A $(mm)^2$	F (kN)	F average (kN)	σ (MPa)	σ average (MPa)
41,30	1,39	1,41	16,83	16,95
41,30	1,43		17,07	
44,70	1,48	1,51	16,55	17
44,42	1,55		17,45	
44,48	1,96	1,99	22,03	22,275
45,06	2,03		22,52	
46,17	2,29	2,34	24,8	25,32
46,43	2,40		25,84	
51,65	72,30	74,95	699,9	725,845
51,61	77,60		751,79	
43,49	74,10	74,35	851,92	854,595
43,51	74,60		857,27	
44,40	73,50	71,81	827,7	811,22
44,12	70,13		794,74	
45,01	80,60	78,90	895,36	881,195
44,52	77,20		867,03	



Transverse compressive strength results of tubular tests

Compressive results				
A $(mm)^2$	F (kN)	F average (kN)	σ (MPa)	σ average (MPa)
11,71	3392,50	3453,37	289,71	299,395
11,37	3514,24		309,08	
10,03	2358,45	2241,28	235,14	238,235
10,70	2582,23		241,33	
10,87	3263,93	3389,08	300,27	304,675
11,37	3514,24		309,08	
11,54	3518,43	3455,46	304,89	297,3
11,71	3392,50		289,71	
10,95	1070,58	1048,81	97,77	95,4
11,04	1027,05		93,03	
10,03	792,37	805,07	79,00	78,93
10,37	817,78		78,86	
10,20	913,92	938,14	89,60	89,77
10,70	962,36		89,94	
10,03	1127,97	1086,85	112,46	109,205
9,87	1045,73		105,95	

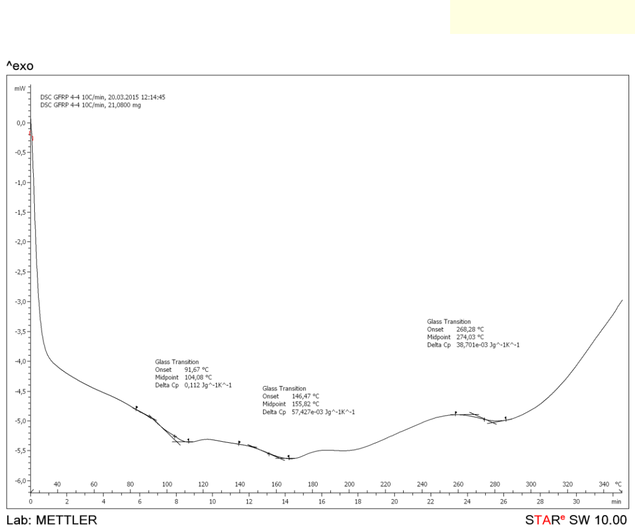


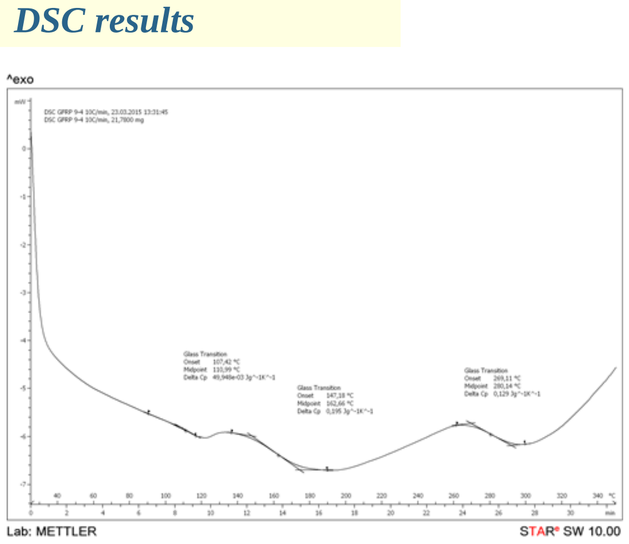
$$y_{tn} = -127.2133 - 0.678x_1 + 1.2079x_2 + 8.9539x_3 + 0.0776x_1x_3$$

$$y_{cn} = 368.4662 - 7.6065x_1 - 0.5817x_2 - 2.7671x_3 + 0.1095x_1x_2 + 0.0284x_1x_3$$

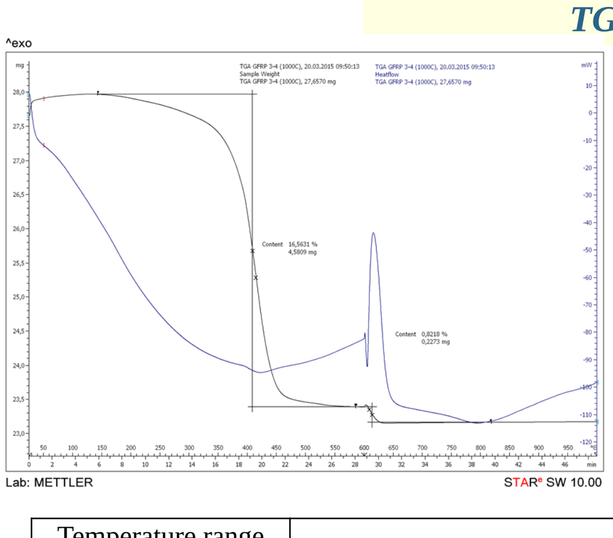
Thermal analysis

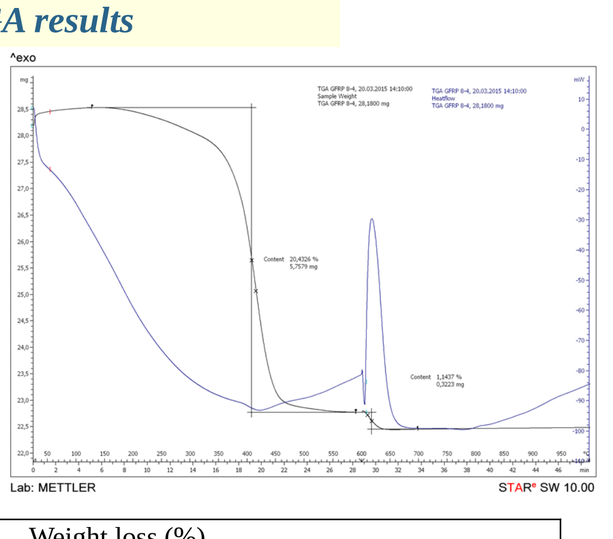
DSC results





TGA results





Temperature range (^{o}C)	Weight loss (%)				
	GFRP 3-4	**GFRP 4-4**	**GFRP 7-4**	**GFRP 8-4**	**GFRP 9-4**
150 - 600	16,5631	15,6111	20,2401	20,4326	54,4510
600 - 1000	0,8218	0,6400	1,0401	1,1437	2,7011

Conclusion

Experimental measurements of the mechanical properties of composite pipes for determined ranges of winding parameters have been carried out implementing 2^3 full factorial experimental design. Regression equations were established for hoop tensile and transverse compression strengths as a function of the winding velocity, fiber tension and winding angle of the fibers. The experimental procedure described in the present work is sufficient to show the influence of the winding parameters on the tensile and compression properties of composite pipes produced by filament winding technique. The tensile and compression test results indicated that the change of the winding angle causes a huge variation in the final mechanical results, whereas the influence of the other two parameters: winding velocity and fiber tension is much lower and the interaction of the factors, has a negligible effect on the response. Very good agreement has been found between experimental and calculated values. It was observed that if the study domain is precisely established (narrow enough), the full factorial experimental design can be employed to give good approximation of the response, i.e. stress of peak values. From the results of thermal characterization of the composite pipes, it was concluded that all filament wound pipes have a good thermal stability and their weight loss was observed at temperature interval from 600 ^{o}C to 1000 ^{o}C. Based on the measurements for the glass transition and rate of cure, it was concluded that crosslinking reaction between the resin and fibers in the filament wound pipes is already reached in all composites.