INFLUENCE OF PLASMA TREATMENT ON THE RESULTING USEFUL PROPERTIES OF TAPES MADE OF GLASS FIBERS

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ABSTRACT

The study deals with the treatment of glass fiber tapes to form a composite suitable for further processing for example weaving, knitting, etc. It is observed the effect of plasma pretreatment, which is applied to glass fibers before the resin application. The pre-treatment affects resin adhesion to the fibers and thus the resulting mechanical properties. The resin is used to bond the fibers and to ensure the processability of the resulting tape. In order to improve the mechanical properties and overall strength of the tape, additives are added to the resin such as ash, graphite, carbiso, clays etc. Additives are also plasma modified before mixing into the resin. For plasma treatment is used the Piezobrush plasma PZ2, which is based on the direct, electric discharge at an openly operated piezoelectric transformer (PT). The Piezobrush® has been conceived to be an efficient handheld unit. At a maximum power consumption of 30 W, cold active plasma with a temperature of ~ 50 °C is generated. Detailed investigation of tensile forces like breaking force, deformation at break and initial modulus was conducted. The results showed a significant difference between the samples. Tape hardness was also measured using a macro hardness tester with Berkovicz indentor. The effect of plasma pretreatment on adhesion improvement was evaluated by examining the fiber surface structure using an electron microscope and a profilometer.

INTRODUCTION

The demand of lightweight solutions is continuously increasing in many industries like transportation, offshore industries and the sports world. Composite materials can be an ideal solution for those industries. Due to fiber orientation and content can be adapted specifically to the load cases, resulting in weight reduction. In addition, fiber reinforced thermoplastic composites can be reprocessed, recycled and repaired when failure occurs through polymer chain pull out.

Methods of tape preparation

The glass fiber tapes were aligned and attached to the frame. Thereafter, each strip of 35 cm was treated with plasma for 2 minutes. Subsequently, the resin was applied so that each tape had the same weight weight. A silicone screed was used for the application. In the case of nanoparticles, nanoparticles were also plasma pretreated. 2.5 wt% of nanoparticles were added. Thus prepared tapes were allowed to dry. Six samples were tested and subsequently compared in the study.

Tab. 1: Description of tested samples

Sample No.1	Pure tape without resin
Sample No.2	Pure tape with resin with plasma treatment
Sample No.3	Pure tape without resin without plasma treatment
Sample No.4	Tape with fly ash particles, with plasma treatment
Sample No.5	Tape with carbon particles (carbiso), with plasma treatment
Sample No.6	Tape with graphite particles, with plasma treatment

RESULTS AND CONCLUSIONS

Hardness measurement

Measurement parameters - Acquisition Rate: 10.0 [Hz], Approach distance: 3 µm, Linear Loading Approach speed: 2 µm/min, Max depth: 5.00 µm, Retract speed: 2 µm/min, Loading rate: 1.00 µm/min, Dz sensor in large range, Unloading rate: 1.00 µm/min, Stiffness Threshold: 500 µN/µm

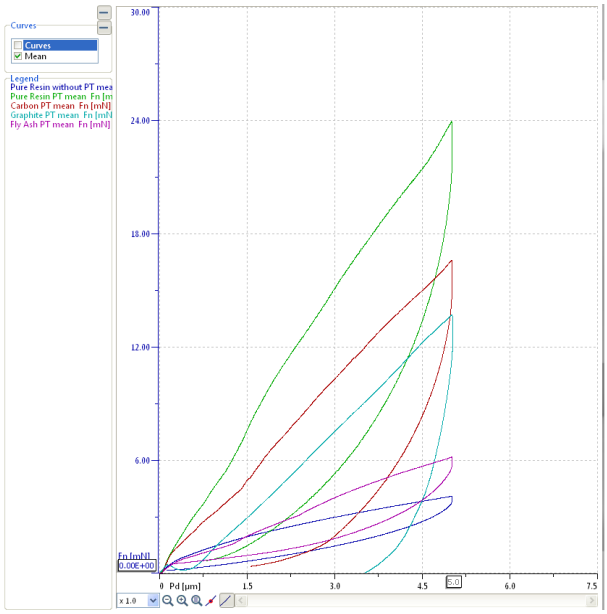
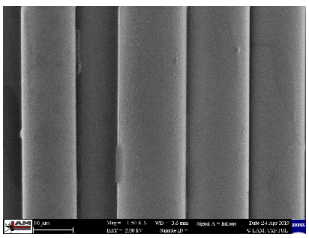


Fig. 1: Average values of measured hardness

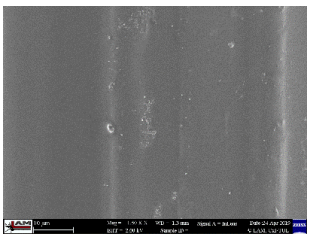
The results of the sample hardness test show that the samples that had been plasma treated before applying the resin had better results. A pure sample without resin was not tested because the indentor could hit in the between of fibers during the measurement.

Monitoring of surface structure changes using SEM

For the scanning electron microscopy analyzes was used a scanning electron microscope of the emission field with high resolution (UHR FEG-SEM Carl Zeiss ULTRA Plus).



Sample No.1



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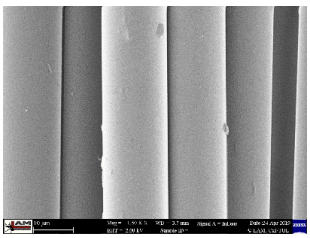
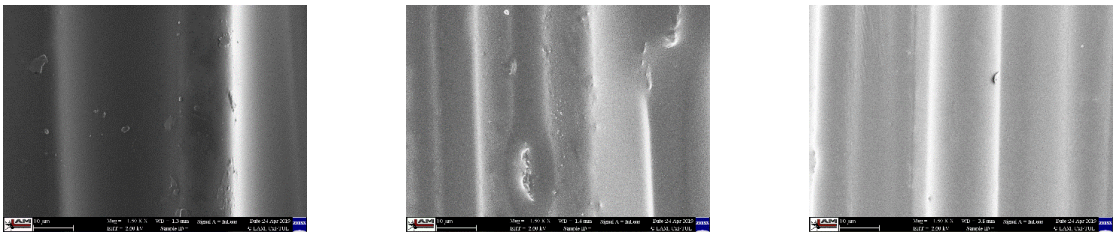


Sample No.3



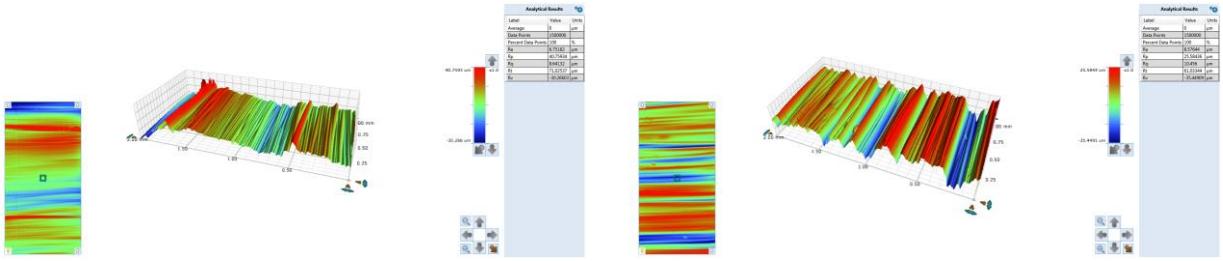
Sample No.4 Sample No.5 Sample No.6

Fig. 2: SEM - surface structure of tested samples

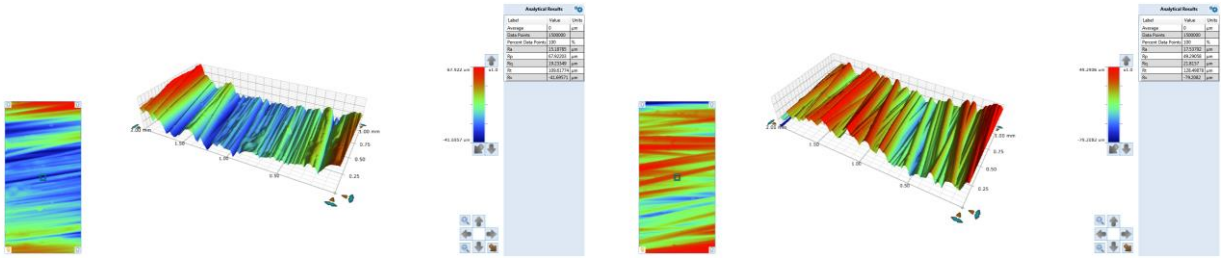
As can be seen from electron microscopy images, plasma pretreatment affects resin adhesion to fibers. Sample number 3, where plasma treatment was not used, shows that no resin is present.

Monitoring of surface structure changes using profilometer

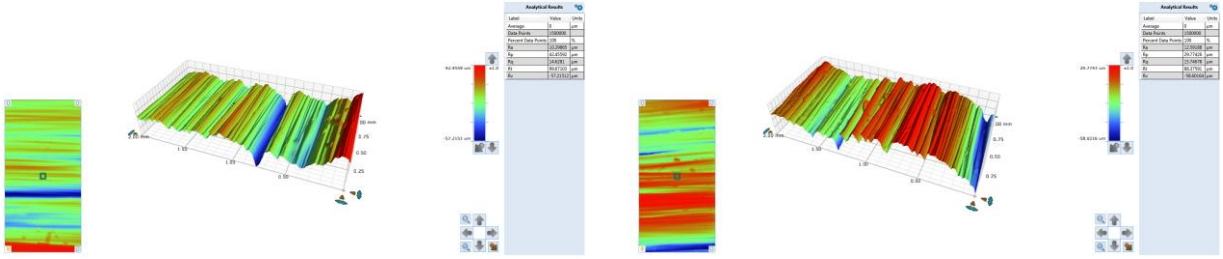
The Dektak XT (Bruker) profilometer was used to measure surface roughness and surface measurement. An indentor with a radius of 2 microns was used. The measured value of Ra is affected by the shape of the surface, the images are rather for a visual assessment.



Sample No.1 Sample No.2



Sample No.3 Sample No.4



Sample No.5 Sample No.6

Fig. 3: Roughness and surface structure of tested samples measured by profilometer

The roughness values determined from the area of 1x2 millimeters are shown in Table 2.

Tab. 2: Measured roughness values

	Ra [µm]
Sample No.1	6.751
Sample No.2	8.576
Sample No.3	15.187
Sample No.4	17.537
Sample No.5	10.298
Sample No.6	12.592

Measurement of mechanical properties

Instron Test

The following measurements were made: Analysis of tensile force (Fmax [N]), modulus (E [Mpa]) and elongation (Amax [%e]). Five measurements were made from which the mean was calculated.

Tab. 3: Measured average values on Instron test

	L0	**b**	**a**	**Fmax**	**Amax**	**Smax**	**E**
	[mm]	**[mm]**	**[mm]**	**[N]**	**[%e]**	**[mm]**	**[Mpa]**
Sample No.2	200	5	0.22	545.77	8.72	17.43	9679.42
Sample No.3	200	5	0.22	526.65	7.57	15.15	12940.76
Sample No.4	200	5	0.22	464.38	5.58	11.16	10281.59
Sample No.5	200	5	0.22	590.90	7.23	14.46	9907.52
Sample No.6	200	5	0.22	609.28	6.54	13.08	9738.79

Bending tester TH-7

Bending stress of the tapes was carried out to determine the mechanical resistance. The measurement results in the determination of the bending stiffness of the samples. The load range for all samples except sample No.1 was 4N. For sample No.1 was the range reduced to 400 mN for non-measurability in the previous range. Cyclic combined stress (bending) has been set. The test was repeated three times on each sample, 1 measurement consisting of 10 cycles.

All samples after the first cycle had broken the tape structure. During subsequent cycles, the bending force decreased. The following table shows average values of measured forces.

Tab. 4: Measured average values of bending stiffness

	Bending force [mN]
Sample No.1	16.92
Sample No.2	241.32
Sample No.3	235.28
Sample No.4	252.35
Sample No.5	244.38
Sample No.6	322.13

As can be seen from Table 4, the plasma pretreatment does not have as much influence on the bending stiffness as the resin itself. Higher bending stiffness was achieved by using Graphite as an additive.

It can be seen from the surface structure measurement results that the plasma pretreatment has a significant effect on resin adhesion to the fibers. The influence of plasma pretreatment on the resulting mechanical properties is rather negligible. The use of resin affects the mechanical strength and resistance. The resin-free glass fiber tape alone achieves the inadequate results needed for further handling of the tapes.

ACKNOWLEDGMENTS

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