

The effect of laser assisted tape placement processing conditions on flexural strength of in-situ carbon fiber/PEEK laminates

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Abstract

Laser-assisted automated tape placement (LATP) has great potential for cost-effective production of thermoplastic parts. The purpose is to investigate how LATP processing conditions affect the flexural strength of laminates made from carbon fibers and polyether ketone (PEEK). The experiments were made by processing the prepreg under different conditions, and the most influential factors were taken into account: laser temperature, compact pressure of the roller, and laser placement angle. Flexural strength tests were performed on all manufactured specimens, and some conclusions regarding process parameters and the ultimate properties of composite specimens were developed based on the experimental data received.

Experimental procedure

MATERIALS using for samples

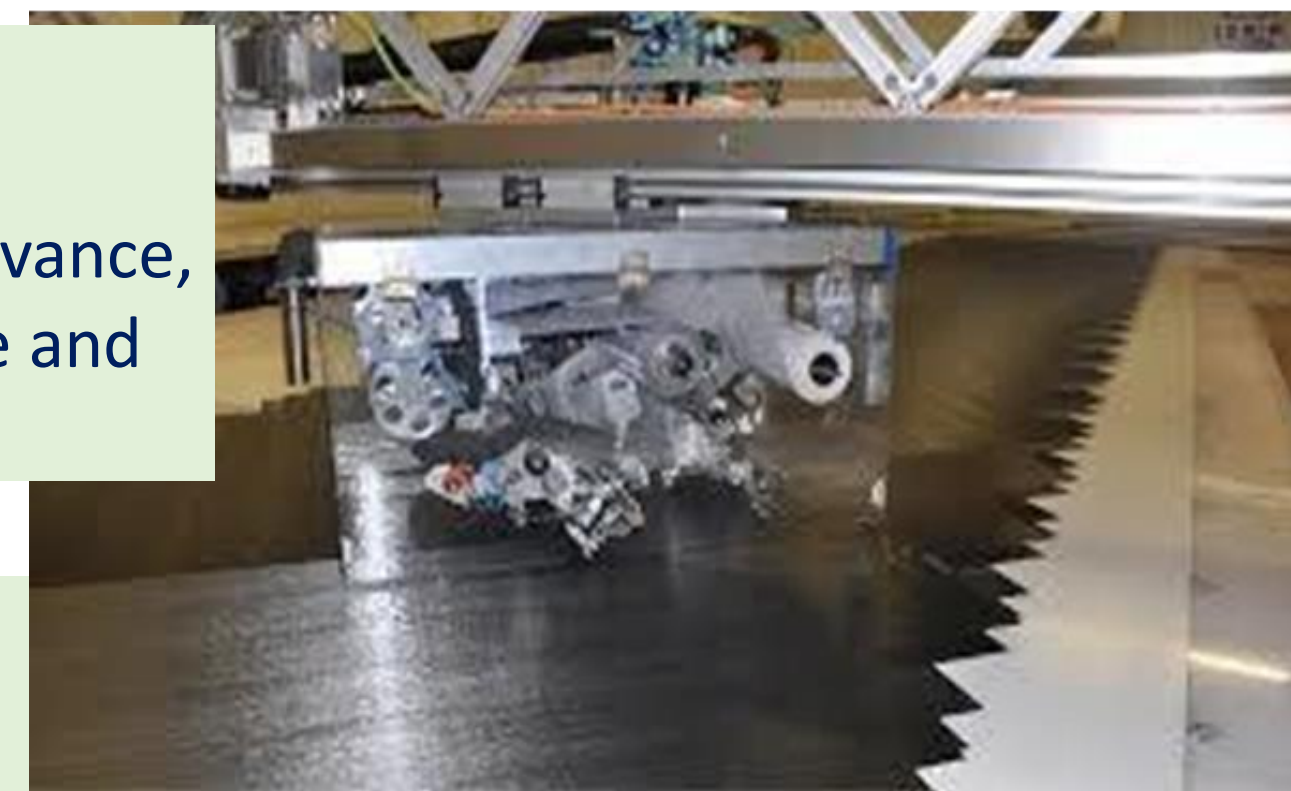
UD prepreg: PEEK/AS4 carbon fibers



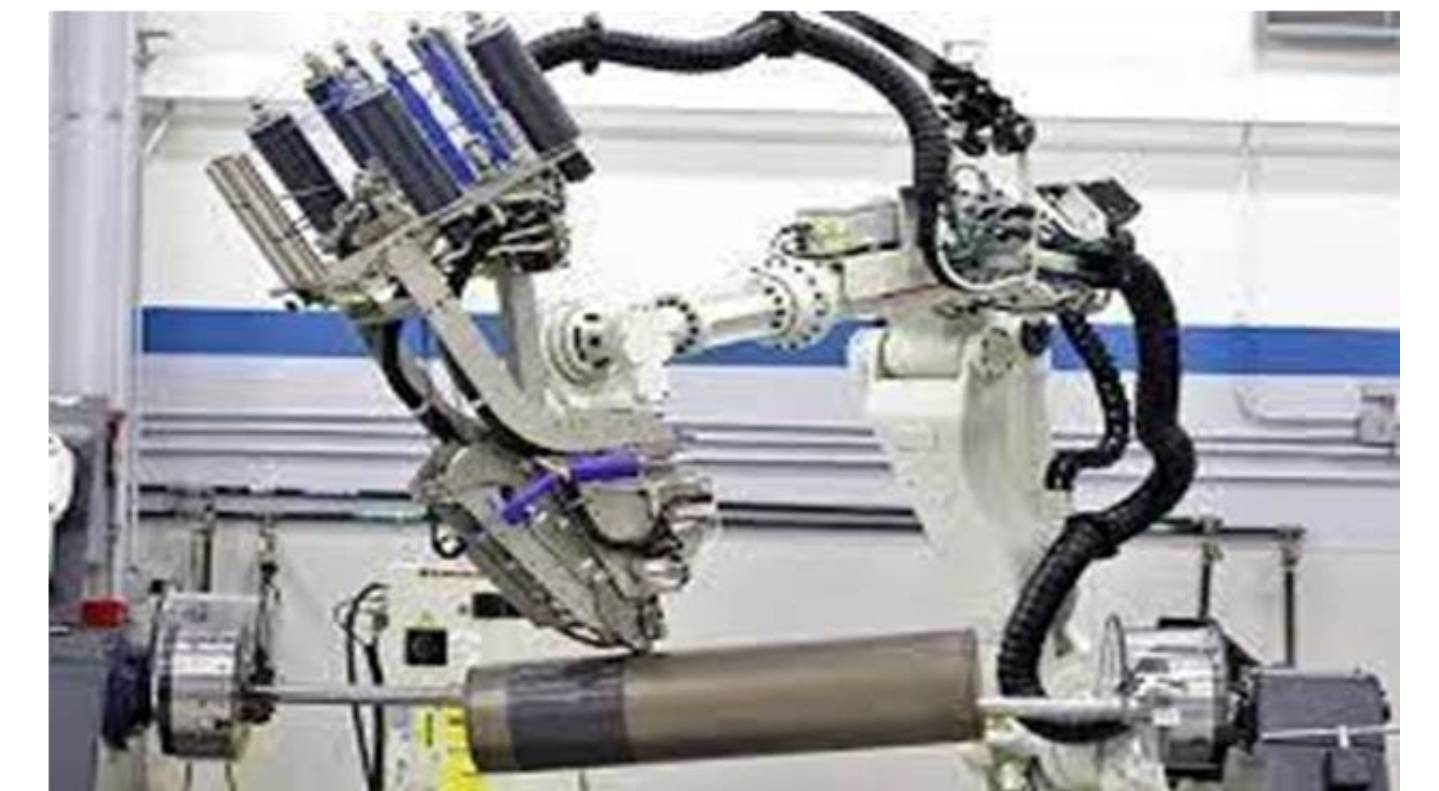
- new production technologies,
- are still being researched and improved,
- promising technology for fabrication of advance, aerostructures and structures for automotive and other industries.

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

ATL



AFP

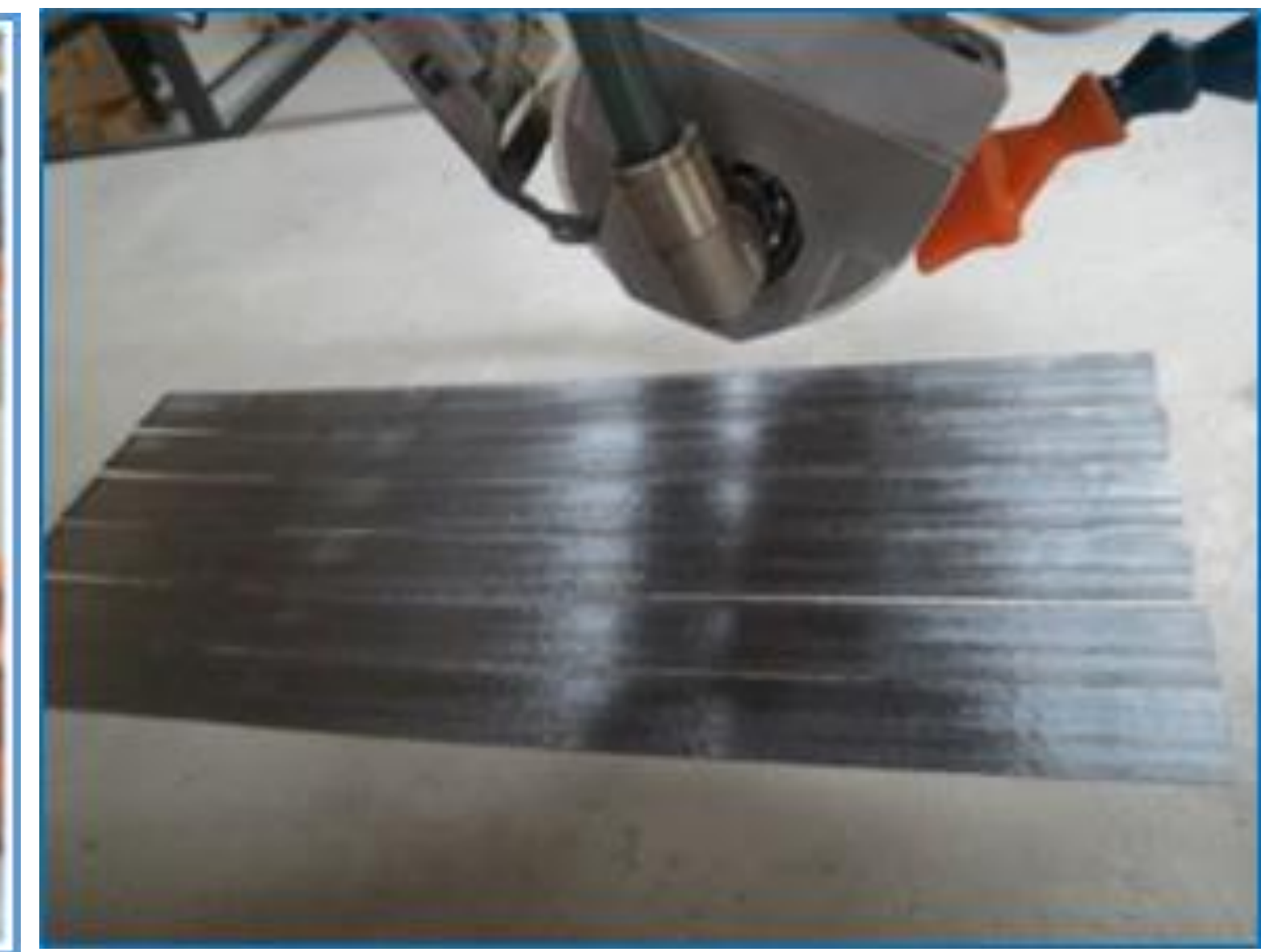
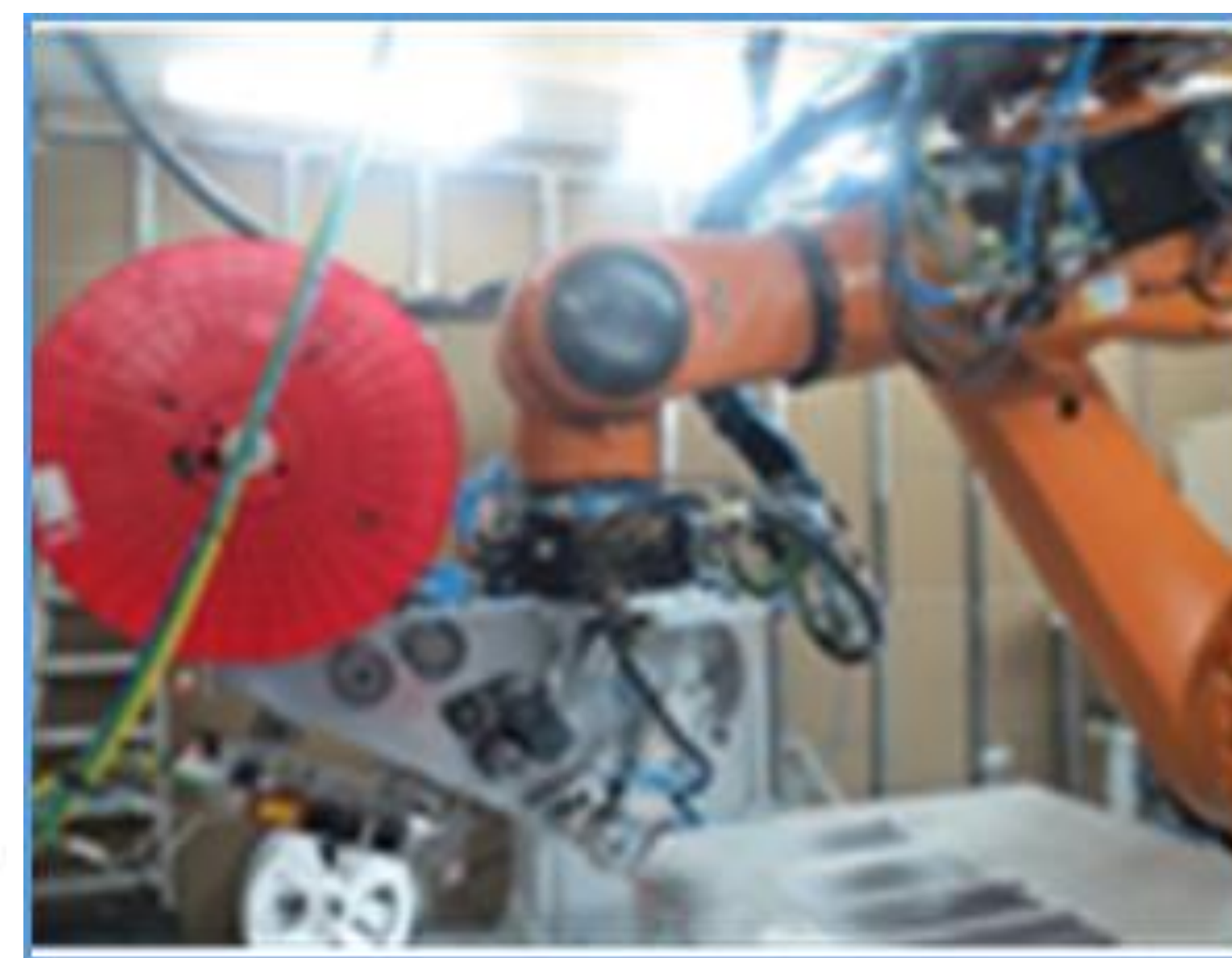
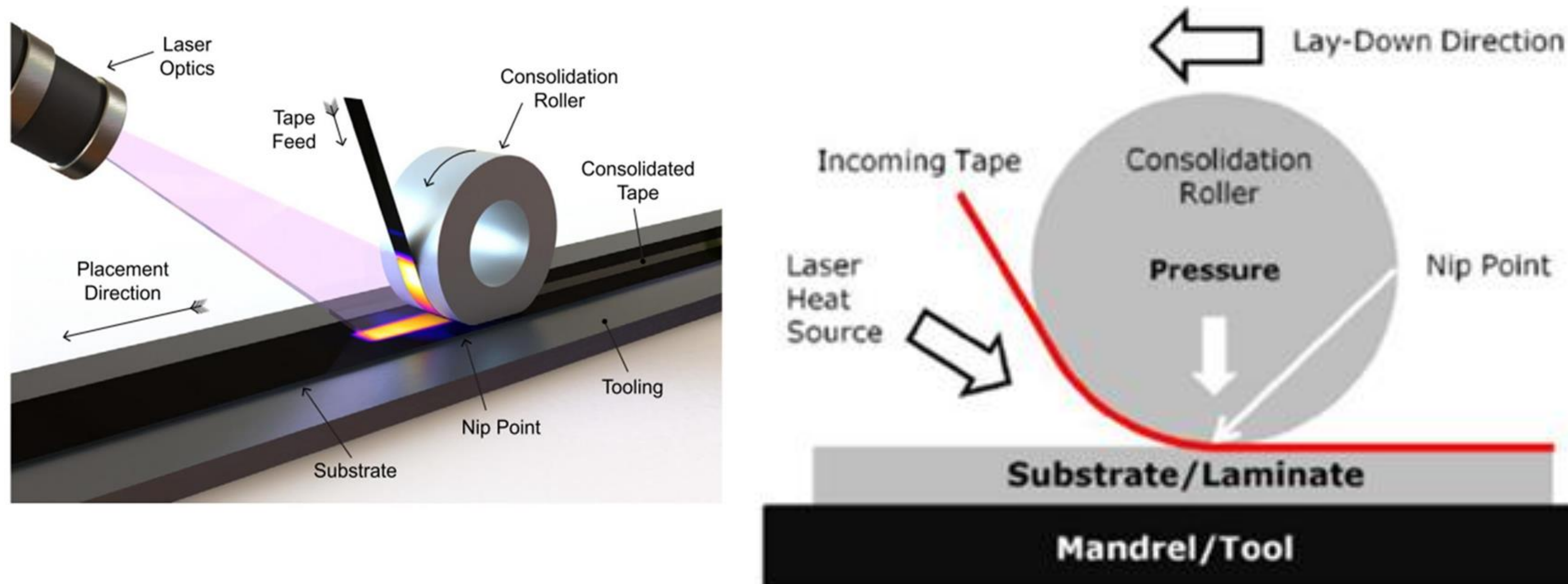


Composite specimens with different technological parameters (all possible combinations of the parameters - 8 different samples) were produced with help of laser-assisted automated tape placement head (LATP)

A tape placement process involves pulling of the thermoplastic prepreg tape from a spool through the feed and guide assembly. On the way to the consolidation roller, the tape is heated on temperature (based of the type of polymer) using a laser. The tape is then placed on the tool and consolidated with a roller. During the tape laying, several factors were observed: laser temperature, compact pressure of roller and laser placement angle, so composite plates with thickness of ~1,5 mm (8 layers prepreg) were manufactured. An investigation of the effect of technological parameters on mechanical properties of laminate panels was performed. The flexural testing was performed according to ASTM D790, using test rupture. Based on the three-point bending test (3pb), prepared specimens were elongated till rupture with help of test fixture and the flexural strength is calculated respectively, according to the standard.

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

In Situ placement process



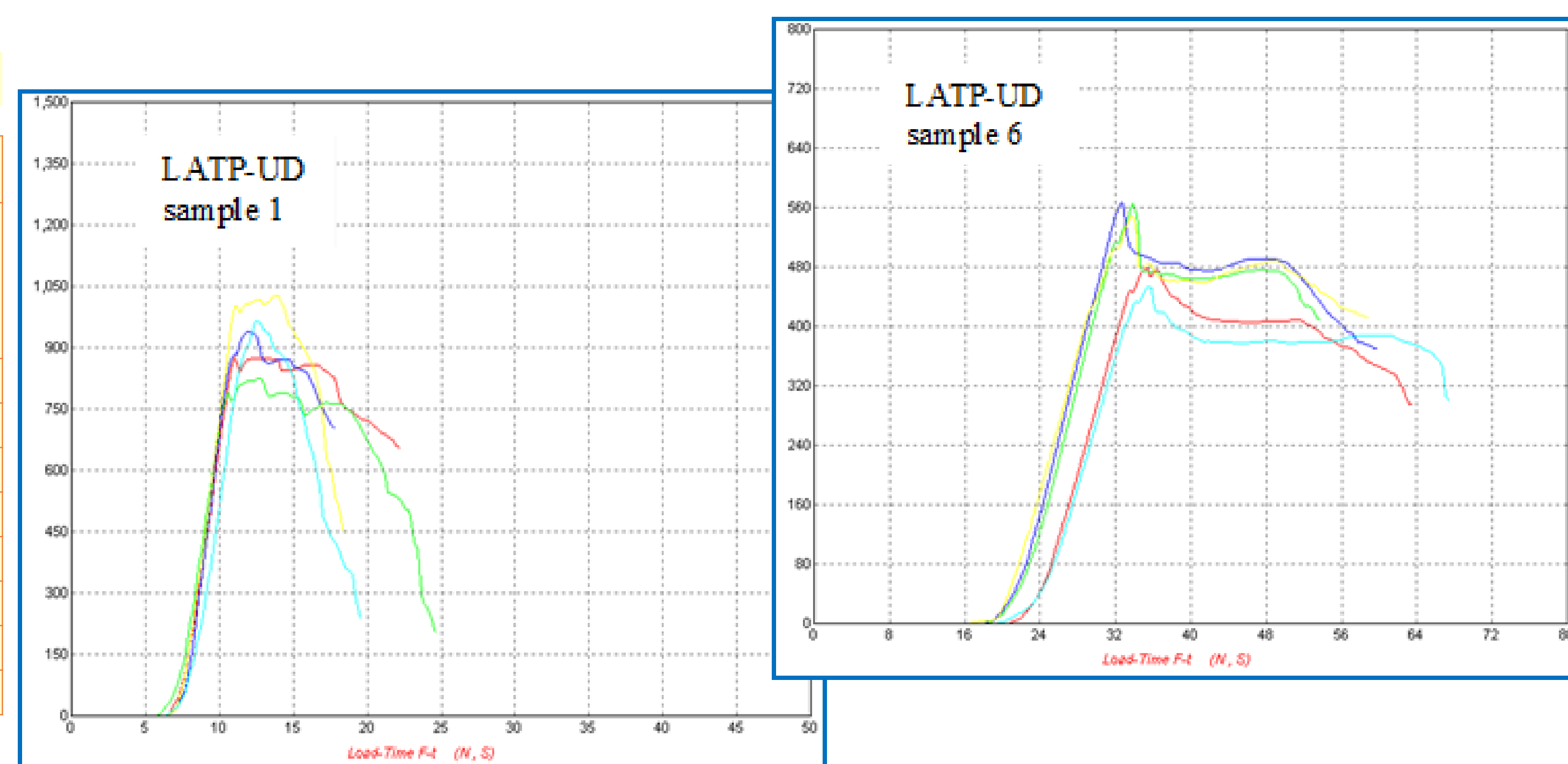
Schematic representation of of automatic tape laying process

Automatic laser - assisted of UD laying

Results and discussion

Condition of the experiments and flexural test results

Number of exp.	Sample designation LATP-UD			Test results
	Laser temperature, °C	Laser angle, °	Compact pressure, N	Flexural strength, MPa
1	380	25	380	1036,81
2	360	25	380	941,73
3	380	22	380	1011,50
4	360	22	380	927,41
5	380	25	270	903,88
6	360	25	270	858,90
7	380	22	270	921,83
8	360	22	270	892,37



The test results indicated an effect of compact pressure of roller and laser temperature on mechanical properties of composite specimens. Namely, the bigger compact pressure of roller and higher laser temperature led to a higher flexural properties of laminate panels. In a polymer composite, each layer has contribution to the whole strength, and when one of the layers in the structure starts to fail, it cracks the matrix around and there appears an increase in the strain. The strain response of the laminate is restored but the load carrying thickness of the panels is decreased due to the failure of one of the layers. As the wall thickness of the laminate panels is decreased, it cannot carry more load anymore, and fails

The load-time curves of the specimens 1 (five replications) are similar and the laminated samples have a linear behavior up to cracking of the some layers of samples. The curves have an appearance which is like zigzag at the higher values of the force which corresponds to the cracking of the fiber layers. In the case of the specimens 6 there is a linear behavior up to cracking of some layers of fibers but the samples are still not destroyed. With continuing of the force, the curves continue to have a view which is like linear up to cracking of the samples.

It can conclude that high quality of laminates made by LATP process depends on the processing parameters fed to the LATP system. Moreover, the compaction force applied during the lay-up process and the laser temperature play a crucial role in achieving of obtaining of defect-free laminates using the thermoplastic UD prepreg materials.