UNION OF ENGINEERS AND TEXTILE TECHNICIANS OF SERBIA

AND

UNION OF ENGINEERS AND TECHNICIANS OF SERBIA
FACULTY OF TECHNOLOGY AND METALLURGY IN BELGRADE
FACULTY OF TECHNOLOGY, SHTIP, NORTH OF MACEDONIA
SOCIETY FOR ROBOTICS OF BOSNIA I HERZEGOVINA
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CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY

VI MEĐUNARODNA NAUČNA KONFERENCIJA

SAVREMENI TRENDOVI I INOVACIJE U TEKSTILNOJ INDUSTRIJI

CT&I TI

PROCEEDINGS

ZBORNIK RADOVA

EDITOR: Prof. dr SNEŽANA UROŠEVIĆ

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PREFACE

The 6 th International conference "Contemporary Trends and Innovations in the Textile Industry" CT&ITI 2023, is co-organized by the Union of Engineers and Textile Technicians of Serbia, the Union of Engineers and Technicians of Serbia, the Faculty of Technology and Metallurgy in Belgrade, the University of Faculty of Technology, Shtip, North of Macedonia, Society for Robotics of Bosnia i Herzegovina and Balkan Society Of Textile Engineering-BASTE of Greece.

The Ministry of Science, Technological Development and Innovation of the Republic of Serbia of the Republic of Serbia recognized the importance of this Conference, and thus, supported it.

The aim of this Conference is to consider current technical, technological, economic, ecological, R&D, legal and other issues related to the textile industry, then the application of contemporary achievements and the introduction of technical and technological innovations in the production process of fiber, textile, clothing and technical textile by applying scientific solutions in order to improve the business and increase the competitive advantages of the textile industry on the domestic and global market.

Leading scientists and experts from the Balkans and other countries, working at faculties, textile colleges and institutes, but also individuals who professionally deal with the issues at hand are taking part in this Conference.

The Conference program involves papers dedicated to the scientific and practical aspects of the following topics: Textile and Textile Technology, Textile Design, Management and Marketing in the Textile Industry and Ecology and Sustainable Development in the Textile Industry. The Conference program includes 54 papers, and a total of 132 participants from 16 countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Germany, Greece, India, Latvia, North of Macedonia, Portugal, Russia, Serbia, Spain, Slovenia, Turkey and Ukraina.

Therefore, this Conference is an opportunity for establishing scientific, educational and economic cooperation of our country with other countries. Certain number of papers by domestic authors present the project results dealing with fundamental research and technological development, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

I would like to thank all those who have made it possible to organize the conference Contemporary Trends and Innovations in the Textile Industry and make it a success. First, I would like to thank the Scientific and Organizing Committee for working hard, spending countless hours and finding the best solutions for numerous organizational aspects of our Conference. Also, I would like to express my gratitude to all sponsors who believed in the importance of this Conference and co-financed it. I also thank all the other institutions that supported the Conference in various ways, because without their support, the Conference could not have been organized. Last but not least, I would like to thank plenary lecturers, all authors and co-authors and guests for their participation in the Conference.

On behalf of the Organizing Committee

Prof. dr Snežana Urošević, president

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PLENARY LECTURES

UTILIZING VACUUM BAGGING PROCESS TO PRIPARE CARBON/EPOXY COMPOSITE LAMINATES

Marija Stoicovska[1], Frosina Vielickova[1], Sara Srebrenkoska[2], Svetlana Risteska[3], Sanja Risteski[1], Vineta Srebrenkoska[1*]

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ABSTRACT: *In the frame of this work, composite laminates based on unidirectional carbon/epoxy prepreg were produced by using of by Automated Tape Laying (ATL)/ Automated Fiber Placement (AFP) and vaccum bagging processes. This research based on unidirectional carbon fiber/epoxy composites shows the effect of fiber architecture on mechanical properties using a automated tape/fiber laying procedure followed by the vacuum bagging process method. The properties of the prepreg material have been tested and some mechanical properties of the obtained composite laminates has been performed. The vacuum bagging method showed improvement in tensile strength and modulus.*

Keywords: *automation, layup, vaccum bagging, prepreg, laminates.*

KORIŠĆENJE PROCESA VAKUMSKOG PAKOVANJA ZA PRIPREMU UGLJENIK/EPOKSI KOMPOZITNIH LAMINATA

APSTRAKT: *U okviru ovog rada proizvedeni su kompozitni laminati na bazi jednosmernog ugljenik/epoksidnog prepregа primenom procesa automatskog postavljanja traka (ATL)/ automatsko postavljanje vlakna (AFP) i vakumskog pakovanja. Ovo istrazivanje zasnovano na jednosmernim karbonskim/epoksidnim kompozitima pokazuje efekt arhitekture vlakana na mehanička svojstva korišćenjem automatizovane procedure polaganja trake/vlakana praćene metodom procesa vakumskog pakovanja. Ispitane su osobine prepreg materijala i određene mehaničke osobine dobijenih kompozitnih laminata. Metoda vakumskog pakovanja pokazala je poboljšanje zatezne čvrstoće i modula.*

Ključne reči: *automatizacija, polaganje, vakumsko pakuvanje, prepreg, laminati.*

1. INTRODUCTION

In the automotive, aerospace and ship industry, carbon/epoxy composites are used extensively since the mechanical strength, chemical resistance and service temperatures requirements are fulfilled apart from higher fatigue strength and higher corrosion resistance [1,2]. In recent years, prepreg material, which is an intermediate material has gained its importance in manufacturing structural composite components as these materials allow to adjust reinforcement positioning, thickness, number of layer and their orientations in the molding. Composites made by hand lay-up process can be seen in several works as shown in the literature [3]. However, composites fabricated by prepregs utilize hand lay-up process that leads to non-uniform deposition of epoxy. Parts manufactured by using prepregs are clean and offer ease in manufacturing of complex geometries with almost 60% fiber volume fraction. Hence, in this work, our objective was to make prepreg based composites with optimized curing cycle [4].

The structures made of advanced composites have been majorly manufactured by hand layup of prepreg tapes to produce composite parts that are finalized by a consolidation and a curing process in an autoclave. However, widespread use of composite materials for aerospace, automotive and other applications has been limited due to high manufacturing costs, long processing times and size limitations of an autoclave. To achieve both desired quality and lower costs, for manufacturing high performance composite structures, the applying of automated manufacturing process with advanced prepreg systems has to be done [5-7]. This method rely on the robotized layup of bands of unidirectional reinforcement material allowing more accurate and more repeatable manufacturing process [6-9]. In this group, two main methods can be identified Automated Tape Layup (ATL) and Automated Fiber Placement (AFP). ATL makes use of a robotic arm to layup tapes (up to 150mm wide) of unidirectional prepeg and benefits from high productivity for large and simple flat parts. Therefore, the manufacturing of more complicated parts can be handled by AFP but with a lower productivity than ATL. For ATL and AFP processes, one of the manufacturing issues is the determination of successive courses trajectories [10-13].

In this paper, study of the influence of fiber orientation on the structural and mechanical properties of laminate manufactured with help of ATL technology and vacuum bagging process is presented.

2. EXPERIMENTAL

The material used in this paper was unidirectional (UD150 IM7 12K/M21) carbon fiber/epoxy prepreg with a 34 wt.% nominal resin content (Hexcel, France). Prepreg is a semiproduct consisting of reinforcing fibers and thermosetting or thermoplastic polymer matrix. This material can be further processed at a certain temperature depending on the polymer matrix and the appropriate pressure for forming a composite structure with certain strength characteristics.

The composite laminates were produced by using a laser assisted tape layng head, manufactured by Mikrosam, Macedonia. Head is attached to a robot arm, as it is shown in Specimens unidirectional laminates were produced with 8/14 layers of UD prepreg and they were processed at appropriate temperatures with vacuum bagging technology (show at Figure 1).

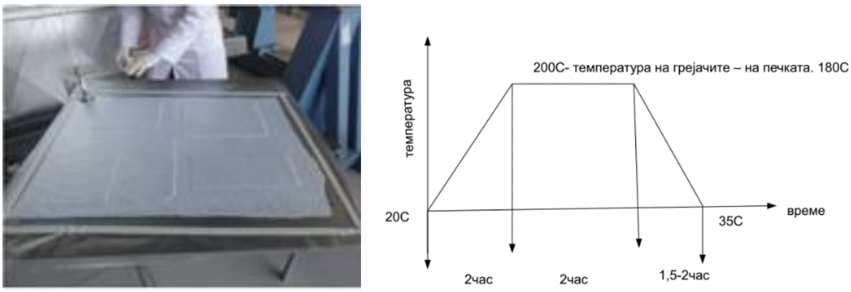

Figure 1: Vacuum Bagging of composite laminates/ Curing curve for vacuum bagging: time – temperature

Manufactured composite laminates had different angles on UD prepreg placement. Codes of unidirectional laminates manufactured with different design (laying angle) are shown in table 1.

Table 1: Properties of prepreg and prepared unidirectional laminates

Properties of manufactured prepreg		
Volatile content (%)	<1	
Mass resin content (%)	30-36	
PAW (g/m^2)	300	
Prepared unidirectional laminates		
Codes of composite samples	**Parameter level**	
	technology of placement	laying angle
1	ATL	0
2	ATL	90
3	AFP	0
4	AFP	90

Tensile properties of the composites such as tensile strength and the modulus (ASTM D 3039) were determined. The properties of manufactured samples were determined with test in accordance with the procedure described in standard. For that purpose computer controlled universal testing machine (UTM) Hydraulic press, SCHENCK- Hidrauls PSB with maximal load of 250 kN, constant crosshead speed of 5 mm/min was used. Load and displacement were recorded by an automatic data acquisition system for each sample. Minimum four reproducible tests were conducted for each sample at room temperature.

3. RESULT AND DISCUSSION

Manufactured composite samples were clamped and tensile tests were performed. The tests were closely monitored and the load at which completed fracture of the specimen occurred has been accepted as breakage load. Load-displacement curves were plotted for every sample and values for stress, strain and module of elasticity were calculated as average. The flexural stress (σ) in the outer surface of the test specimens occurred at the midpoint. These stresses were determined from the relation [16]:

$$\sigma = \frac{F}{A} \quad (1)$$

Where, σ is the Tesnsile strength (MPa), F is the load (N), A is the area (mm^2), b is the width of the specimen (mm), and h is the thickness of the specimen (mm).Tensile modulus of elasticity (E) and strain (ε) of the composite specimens were determinate using equations according standard [16].

Table 3 shows a summary of the flexural properties for composite laminates.

Received results from performed tests on laminated composite samples are given in table 2, where maximal flexural strength of 1925.85 MPa for sample Nº3 and minimal flexural strength of 7.33 MPa for sample Nº6 can be observed.

Comparison between results of specimens manufactured at same technological parameters, but different fiber orientation can give a notice that all samples tested at UD direction (0^0) had performed better mechanical properties in comparison to the samples tested at CD direction (90^0). This means that fiber direction directly affects Tensile strength of laminated composite samples up to 99%. Received average results from tensile tests are shown in table 2.

Table 2: Tensile properties for composite laminates

Samples	Tensile tests			
	technology of placement	laying angle	Strength (MPa)	Modulus (GPa)
1	ATL	0	1546.21	17.33
2	ATL	90	147.31	7,11
3	AFP	0	1831.08	21.78
4	AFP	90	221.86	8,46

Comparison between results of specimens manufactured with different fiber orientation can give a notice that all samples tested at UD direction (0°) had performed better mechanical properties in comparison to the samples tested at CD direction (90^0). This means that fiber direction directly affects tensile strength of laminated composite samples.

4. CONCLUSION

Experimental measurements of the tensile strengths of laminated samples for determined ranges of parameters have been carried. The results for tensile strength were analyzed as a function of the technology of placement, polymerization technology and laying angle. The experimental procedure described in the present work is sufficient to show the influence of the fiber architecture on the tensile properties of laminated samples . The test results indicated that the change of the laying angle cause a variation in the final mechanical results, whereas the influence of the technology of placement (AFP/ATL) is much lower, and the vacuum bagging method has showed improvement in tensile strength and modulus.

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