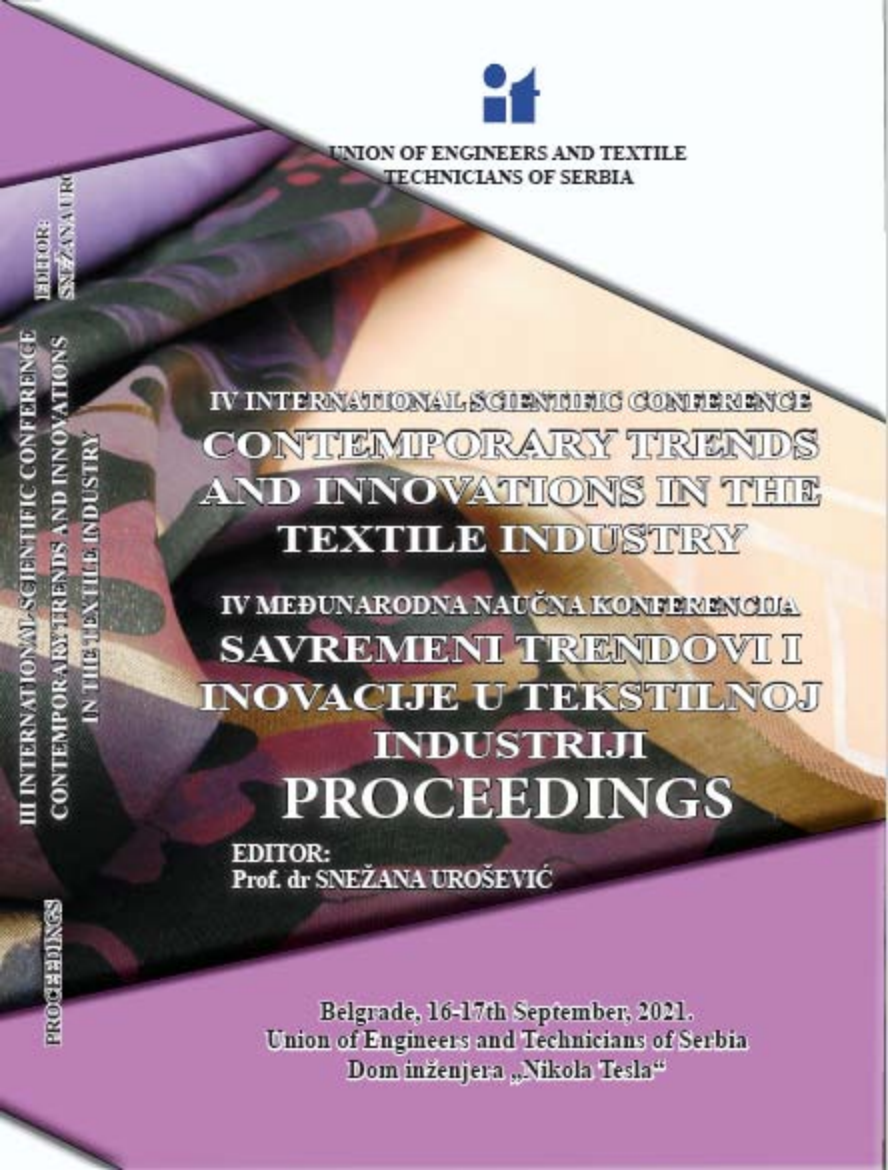
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IV MEĐUNARODNA NAUČNA KONFERENCIJA
SAVREMENI TRENDOVI I INOVACIJE U TEKSTILNOJ INDUSTRIJI
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EDITOR:
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CT&I TI 2021

PROCEEDINGS

ZBORNIK RADOVA

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Belgrade, 16-17 th September, 2021
Union of Engineering and Technicians of Serbia
Dom inženjera „Nikola Tesla“

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"CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY" CT&ITI 2021

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PREFACE

The 4 th International conference "Contemporary Trends and Innovations in the Textile Industry" CT&ITI 2021, 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 Education, Science and Technological Development 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 56 papers, and a total of 129 participants from 16 countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, India, Latvia, North of Macedonia, Montenegro, Portugal, Romania, Russia, Serbia, Slovenia, Turkey and Ukraine.

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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IV International Conference
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MECHANICAL AND MORFOLOGICAL ANALYSES OF LAMINATED PLATES

Sara Srebrenkoska[1], Svetlana Risteska[2]

[1]University “Goce Delčev”, Štip, Faculty of Technology, North Macedonia
[2]Institute for Advanced Composites and Robotics, Prilep, North Macedonia

ABSTRACT: *In this paper, the flexural strength on samples of laminate plates obtained from three types of prepreg tapes based on carbon fiber and thermoplastic polymer matrices PPS and PEEK with manual laying and compression molding are analyzed. Microscopic analyzes with optical microscopy of the specimens are also provided to study the microstructure of prepreg materials and laminates and their relationship to process parameters.*

Keywords: *flexural strength, thermoplastic prepreg, manual laying, compression molding, optical microscopy.*

MEHANIČKE I MORFOLOŠKE ANALIZE LAMINIRANIH PLOČA

APSTRAKT: *U ovom radu se analizira čvrstoća na savijanje na uzorcima laminatnih ploča dobijenih od tri vrste ogrebotina, na bazi ugljeničnih vlakana i termoplastičnih polimernih matrica PPS i PEEK ručnom ugradnjom i presovanjem. Takođe se pružaju mikroskopske analize sa uzorcima optičke mikroskopije za proučavanje mikrostrukture prajmera i laminata i njihov odnos prema procesnim parametrima.*

Ključne reči: *čvrstoća na savijanje, termoplastični prepreg, ručno polaganje, presovanje pod pritiskom, optička mikroskopija.*

1. INTRODUCTION

Composites are ideal materials for aerospace, automotive and other mechanical industries where the use of high-performance advanced materials directly enhances their capability. 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 [1]. Compression moulding is a composite manufacturing process normally used to produce composite components in high production volume such as automotive components [2]. These is used with thermosetting plastics. The thermoset plastic material may be in free-flowing granular form or a viscous material. The material is placed in a hot mold, and the mold is closed by a hydraulic press [3].

The compression moulding process is one of the most important technologies for obtaining polymer composite materials. This process uses a suitable tool that fulfils the function of a mould. Additionally, a hydraulic press is used to heat the tool and relatively high pressure to network the fibres and resin in the mould. This process is a widely used process. Minimizes the cost of preparing parts, almost eliminates material waste, reduces secondary finishing, and requires minimal effort. The process can be easily automated, providing high productivity with very good uniformity and quality of manufactured parts [4, 5].
In this paper, laminate plates are obtained from three types of prepreg tapes based on carbon fibre and thermoplastic polymer matrices PPS and PEEK with manual laying and compression moulding.

2. EXPERIMENTAL

The materials used in this paper was thermoplastic unidirectional (UD) prepreg tape. Prepreg is a semi product 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.
For the investigation in the frame of this paper three types of thermoplastic unidirectional prepreg tapes with width of 25 mm were used, supplied by Supreme:
- CF/PPS: UD prepreg based on AS4 carbon fibre and Polyphenylene sulfide (PPS).
- CF/PEEK: UD prepreg based on AS4 carbon fibre and Polyether ether ketone (PEEK).
And thermoplastic unidirectional prepreg tapes with width of 25 mm, supplied by Tocho Tenax:
- CF/PEEK: UD prepreg based on AS4 carbon fibre and Polyether ether ketone (PEEK).
Eight layers of prepreg with dimensions 300mm x 150mm have been used for the manufacturing of composite laminates. The final curing of preforms has been done in a press machine, using 385N and 530 N pressure, with a predetermined temperature (figure 1), and the conditions for processing the prepregnant materials are given in Table 1.

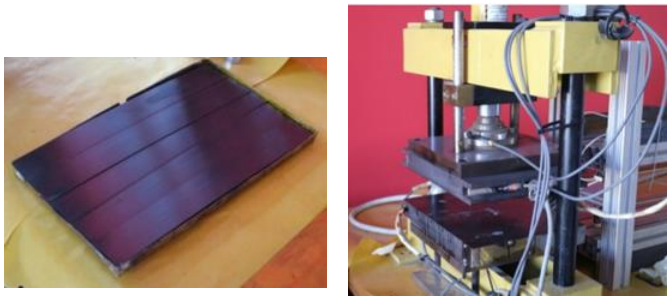


Figure 1: Compresion molding of the thermoplastic prepreg layers.

Table 1: Conditions for processing the prepreg materials.

Type of prepreg	Temperature (°C)	Pressure (bar)	Heating time (min)	Cooling time (min)
PPS, Supreme	290	25	20	60
PEEK, Supreme	350	35	20	60
PEEK, Tocho Tenax	350	35	20	60

Mechanical properties of the composites such as flexural strength and the modulus (ASTM D 790) were determined [6]. The tests samples were carried out at room temperature by using the universal testing machine with max load of 50kN and loading speed of 5mm/min. (figure 2).

Figure 2: Flexural strength test

Also, cross-sectional images were taken from the obtained samples on an optical microscope and the connection of the layers and the content of pores in the laminate were analysed in correlation with the obtained values for the bending strength, i.e. the bonding strength of the layers.

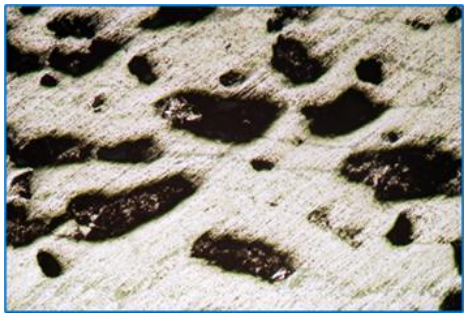
5. RESULT AND DISCUSSION

The results of the testing method of the laminated specimens for determination of the flexural properties are illustrated in Table 2. The results obtained from tests performed on the composite laminated (Table 2) show maximal flexural strength of 884,11 MPa for sample 2 produced on on high level of temperature and molding pressure, and minimal flexural strength of 617,74 MPa for sample 1 produced on the lower level of both factors.

Table 2: Results for the flexural strength of the composite plates

Sample Number		Width, **b** **(mm)**	Thickness, **h** **(mm)**	Loading force **(N)**	Flexural strain, $\sigma_{f\,.}$ **(MPa)**	$\sigma_{f\,sr.}$ **(MPa)**
1	1-1	15,31	1,95	697	628,56	**617,74**
	1-2	15,2	2,16	736	544,86	
	1-3	15,3	2,05	781	637,69	
	1-4	15,28	1,86	671	666,40	
	1-5	15,19	1,77	554	611,17	
2	2-1	15,13	1,87	954	946,64	**884,11**
	2-2	15,07	1,96	875	793,49	
	2-3	15,17	1,96	971	874,74	
	2-4	15,03	1,84	927	956,41	
	2-5	15,11	1,96	939	849,27	
3	3-1	15,17	1,94	1410	730,47	**746,71**
	3-2	15,1	1,89	1624	821,19	
	3-3	15,19	1,95	1251	607,75	
	3-4	15,14	1,92	1611	846,06	
	3-5	15,16	1,85	1332	728,11	

The obtained optical microscope images given in Figure 3. a) CM-1 PPS,Supreme, b) CM-2 PEEK,Supreme and c) CM-3 PEEK,Tocho Tenax clearly show that in the microstructure of the obtained samples there are many defects or pores which means that no intimate contact has been made on the entire surface and there is no good connection between the layers.



a.) CM-1 PPS,Supreme

b.) CM-2 PEEK,Supreme

c.) CM-3 PEEK,Tocho Tenax

Figure 3: Metallographic images from an optical microscope of cross section of laminate shells a) CM-1, b) CM-2, c) CM-U3

6. CONCLUSION

From the obtained results for flexural strength of laminated composite plates and microscopes analyses, can be concluded that the relationship between the layers in the sample marked CM-1 is bad, which reflects the lower value of bending stress (617.74 MPa) compared to the other two samples. Samples marked CM-2 and CM-3, which are based on the same prepreg but from a different manufacturer, have higher bending stress values by about 20% compared to the CM-1 sample. They are obtained at a higher temperature determined based on the thermoplastic matrix PEEK and with higher pressure. From the obtained optical images, Figure 3 b) and c), again many pores between the layers were noticed, but with a smaller dimension compared to those in the sample CM-1. These samples also did not have a good bond between the layers.

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[6] Product Data HexTow® AS4 Carbon Fiber, Copyright © 2014–Hexcel Corporation, Stamford, Connecticut. February 2014.

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