Opponent's Report of the Dissertation

The author of the dissertation: Juan Huang, M.Eng.
Title: Selected Mechanical Prperties of Polymeric Optical Fiber (POF)
Supervisor: Doc. Dr. Ing. Dana Křemenáková
Dissertation opponent: Doc. Ing. Rydlo Pavel, Ph.D.
Study program: P3106-Textile Engineering
Field of study: 3106V015- Textile Technics and Materials Engineering
Scope of work: 85 pages of text, seven pages of annexes

Characteristics of the Work:

The dissertation is focused on the exploration of selected mechanical properties of polymer optical fibres (POF) with the aim to assess the possibilities of application in textile end-uses. Polymer optical fibres (POF) are currently used in many applications. The data communication is an important field of POF applications.
An interesting application, which is the subject of this dissertation, is the use of side-emitting optical fibres with 2-6 mm diameter in textile applications. This allows e.g. the visualization of the contours of people, animals, objects, defining obstacles (stairs, carpet edges) etc.

Chapter 3 describes the basic characteristics of POF, basic relations describing the light propagation in optical fibres and the manufacture of these fibres as well. There is also indicated the construction of POF and the chemical composition of the material used.

In Chapter 4 there are described the methods used for the testing of POF. In this case the tensile test was a basic mechanical characteristic. For this test the tensile testing device Instron was used. Using this test the tensile properties like strength, modulus and strain were obtained.

The nanointendance method and the apparatus Hysitron were used for measuring hardness and tensile modulus. From the measured dependencies there were determined hardness and elastic modulus.

In order to measure the bending properties, the apparatus Flexometer was used. The aim of the testing there was to evaluate the lifetime of POF depending on the number of bending cycles (flex-fatigue testing).

Chapter 5 is an important part of the dissertation, wherein the measurement results including a detailed analysis of the measured dependencies are given. There is possible to indicate the following facts from the analysis that was carried out:

For measuring the tensile properties of laterally radiating optical fibres, depending on their diameter, there was found that the relative strength and elongation decreases with increasing fibre diameter.

With increasing the fatigue cycles, the tensile strength and modulus of elasticity decrease considerably. It is remarkable that the descent rate varies with different fibre diameter; the thicker the fibre, the steeper the descent.

When monitoring the fibre hardness depending on the fibre diameter there was found that the hardness values are higher for the fibres of higher diameter.

When monitoring the number of bending cycles to destruction of fibres there was found that it depends on the fibre diameter. The number of cycles to destruction of the fibre with diameter of 0.25 mm is about 5 times higher than that of 0.5 mm and almost 22 times higher than that of 1 mm.

It would be interesting to verify the above mentioned dependencies using simulation models. The models could be designed, for example, based on the finite element method.

The Means and Methods used in the Dissertation:

For the measurements there were used measuring devices that were available at Faculty of Textile Engineering of TUL. In order to characterize local mechanical properties there was used a modern nanoindentation method. The nanoindentation uses a very sharp diamond tip indenter, which will be impressed with a defined force perpendicular to the surface of the sample. During the measurement there is monitored the dependency of the force on the depth of penetration. The data on hardness, Young's modulus or the viscoelastic properties of the sample can then be obtain from the measured dependencies. The range of forces used for the nanoindentation measurements is in the order of μN to mN. The penetration depth in the sample is in the order of nanometers.

Comments on the Work:

In this work, the author assumes the POF material to be isotropic. Work does not contain detailed confirmation of this assumption.

POF has a core/shell structure. It would be interesting to create a mathematical model (e.g. Finite Element Method) for this composite material and to verify this model based on the measurements that were carried out by the author.

The graphs in Figures 5.34–5.42 are missing the names of individual axes.

Benefits of the Dissertation:

1) Comprehensive view on the mechanical properties of POF with regard to possible applications in textile products;
2) Development of testing methodology;
3) Measurements and analysis of measured results.

Publications of the Author:

The author of the dissertation is a co-author of 12 published works in journals and 25 publications at conferences. Furthermore, she participated in selected chapters in two monographs. I can say that her publishing activities are sufficient.

Questions submitted to the Dissertation:

1) Has POF stress in torsion been examined? Is knowledge of this stress important for optical fibres integrated in textile materials?
2) Has it been analysed if there is possible to use Hooke's law in general form and to describe the properties of the fibre by stress and strain tensors?
3) The fundamental problem of POF use in textiles there is their energy demand given by the large attenuation of light transmission in comparison with glass fibres. What are the possibilities of increasing the intensity of light emission?
4) POF are resistant to bending, which makes their use in textile applications more difficult. Where do you see the possibilities to improve this deficiency?

Conclusions:

In the framework of the dissertation, a methodology of measurement has been developed, numerous measurements were carried out and the obtained data was evaluated and suitably applied to the problem under solving.

Finally, it can be stated that targets of the dissertation have been met.

Based on the above facts **I recommend** This Dissertation for the defense.

V Liberci 21. 3. 2016

Doc. Ing. Pavel Rydlo, Ph.D.
Fakulta mechatroniky,
informatiky a mezioborových studií

Prof. ***Jaroslav Šesták****, Dr.h.c.*
Emeritus Scientist, the Czech Academy of Sciences in Prague
Program Auspice, West Bohemian University, Institute of Interdisciplinary Studies
Visiting professor, New York State University, Business School in Prague

♥ V stráni 3, CZ-15000 Praha 5, tel (+420) (2) 57214234,
Institute of Physics, Cukrovarnická 10, CZ-16253 Praha 6,
Email: sestak@fzu.cz, +420 2 fax 33343184 tel 20318559 ♣

Technical University of Liberec
Faculty of Textile Engineering
Hálkova 6
46117 LIBEREC

In Prague on April 10, 2016

Subject: Opponent opinion of thesis Juan Huang MSc. on the topic

Selected mechanical properties of polymeric optical fibers

The thesis contains 85 pages of text, 149 citations and 39 of her own publications, of which are 12 publications in journals and 2 chapters in books. The work is written clearly and shows authors good insight about problems in preparation, properties, testing and illumination behavior of side emitting optical polymer fibers.

Dissertation is written very clearly and especially for me have personal character, as I have in the past personally participated in experimental studies of the suitability of glass materials for optical waveguides.

Review and experimental parts contain:

The history of polymeric optical fibers
Description of reflection and composition of materials
Experimental methods of study
Discussion of results with respect to strength characteristics
Conclusion and Outlook

The main core of dissertation work is study of tensile properties (relationship between fiber strength and gauge length), nanoindentation testing (in terms of hardness property, creep deformation and interphase properties between core and cladding), tension fatigue testing and flex fatigue testing (based on the number of bending cycles to failure and correlation with flexibility).

In dissertation work study of influence of fabric cover with and without fluorescent on the illumination intensity and enhancement of illumination intensity by creation of lensed end fiber shape is also noted.

Although she is the co-author in a chapter in the book "Selected Properties of Functional Materials" (p. 96, cit. 8.2.1.), surely it would be fair to mention also the

introductory chapter "Background of fiber optics" (TUL FT 2013), which details outlines history and functionality of optical fibers (in the dissertation chapter. 1st). There also no mention of a recent book TUL "Recent Developments in fibrous material science" (TUL FT 2015).

The work could be given a deeper discussion on the definition of the author's own opinion on optimizing processes, including estimates of the prospects for future development.

Overall, I am satisfied with the work, processing and content. I evaluate and classified this work into the standard dissertations handed to the related fields of material research.

The work meets the requirements for the doctoral thesis and meets the requirements of both the Ministry of Education and TUL - Technical University in Liberec and therefore

I recommend

the work for defense and author to award a PhD title.

Sincerely

Jaroslav Šesták

Section of Solid State Physics
Institute of Physics, AV ČR, Praha