J.F. Silva Gomes
Shaker A. Meguid
Editors

M2D2015

Proceedings of the 6th International Conference on Mechanics and Materials in Design

P. Delgada (Azores), Portugal, 26-30 July 2015

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EDITORS' PREFACE

M2D2015 is the sixth international gathering of a prestigious series of conferences coordinated by the International Scientific Committee of Mechanics and Materials in Design. This series of conferences are wholy devoted to advances in mechanics, materials, structural integrity and design. M2D2015 is sponsored by the University of Porto, the University of Toronto and the University of Azores. The conference attracted over 320 participants with 423 accepted submissions from 42 countries out of 620 submissions. These papers were presented in July 26-30, 2015 in the magnificent city of Ponta Delgada, Azores. The conference themes which address novel and advanced topics in Mechanics and Materials in Design focused on analytical and numerical tools at all scales, testing and diagnostics, surface and interface engineering, tribology, mechanical design and prototyping, modes of failure, composite and engineered materials, biomechanics, energy and thermo-fluid systems, impact and crashworthiness and case studies.

We believe that the meeting offered our delegates a forum for the dissemination of their recent work in mechanics and materials and their applications in engineering design, fostered research that integrates mechanics and materials in the design process, and promoted exchange of ideas and international co-operation among scientists and engineers in this important field of engineering.

We are particularly indebted to the authors and special guests for their presentations. Each of the more than 420 contributions offered opportunities for thorough discussions with the authors. Particularly, we acknowledge the excellent contributions of the participants, their innovative ideas and research directions, the novel modeling and simulation techniques, and the invaluable critical comments. We are also indebted to the outstanding keynote speakers who highlighted the conference themes with their contributions and covered the main topics of the conference. We also take this opportunity to thank the members of the International Scientific Committee and the reviewers for their time, effort and helpful suggestions.

We offer our sincere gratitude to the symposia organisers for their efforts and valuable contributions to the success of the event, and the local organising committee for attending to the conference demands and delegates needs.

All in all, M2D2015 was a great success and the credit must go to all the participants for their significant contributions and lively discussions, the keynote speakers for bridging the gap between the different disciplines and the organizing committee for an absolutely superb organization of the meeting in this magnificent city. To all of you, we offer our gratitude.

Given the rapidity with which science is advancing in all areas of mechanics and materials, the next conference in this series (Integrity, Reliability and Failure - IRF 2016) will take place in Porto, Portugal in July 2016. Undoubtedly, we expect IRF2016 to be as stimulating and interesting as M2D2015, as evidenced by the excellent contributions offered in this current event. We look forward to seeing all of you in Porto in 2016.

Shaker A. Meguid and J.F. Silva Gomes

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SEM-American Society for Experimental Mechanics
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JSME-Japanese Society of Mechanical Engineering
IMEKO-International Measurement Confederation
AFM-Association Française de Mécanique
DYMAT-European Association for Dynamics of Materials
INEGI-Instituto de Ciência e Inovação em Engª. Mecânica e Engª. Industrial
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NUMERICAL SIMULATION OF WALL DEFORMATION IN AN ANEURYSM MODEL

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ABSTRACT

This work presents the numerical assessment of the deformation of an artery wall with and without an aneurism. The simulations consider the hyper-elastic behaviour of the artery tissues, taken in consideration the properties of polydimethylsiloxane (PDMS), which are more similar to the biological tissues. The numerical simulations were performed using the commercial finite element routines ANSYS®, by considering the inner the artery fluid flow and the consequent pressure is used to simulate the wall deformation.

Keywords: aneurysm model, polydimethylsiloxane, hyper-elasticity, finite element method.

INTRODUCTION

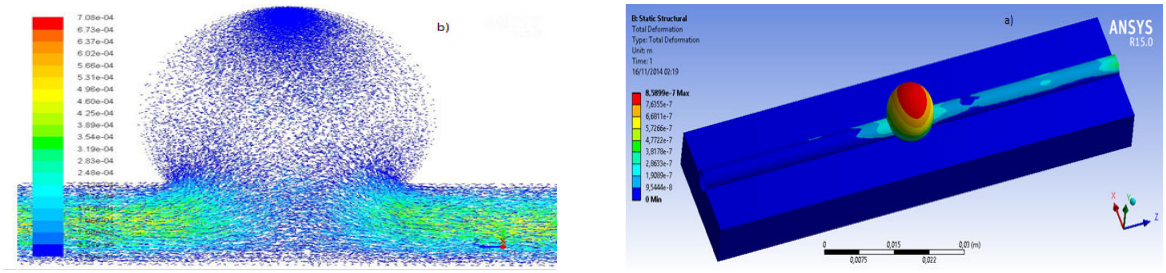
Aneurysms are the fourth most common cause of cerebrovascular disease in adults, after the ischemic attacks, thrombotic and hypertensive cerebral hemorrhage. In Europe, the cerebrovascular diseases are the leading cause of mortality (Branco, 1992). The causes for the occurrence of aneurysms are the deterioration of the arterial wall is the hypertension. Other causes include hereditary connective tissue disease, congenital cardiovascular abnormalities or atherosclerosis. An aneurysm is an excessive dilation of the wall blood vessel that can occur in an artery or a vein. However, there are no known ways to prevent the formation of aneurysms. For that reason, an approach to the study of aneurysms behavior may be made from analysis of the blood flow in this region and deformation occurred caused by blood pressure.

One of the important features in this study relates to the mechanical properties of the arteries tissues. Some studies have shown that arterial tissues have a typical hyper-elastic behavior (Masson, 2008). These materials are characterized by exhibiting high deformation prior to reaching the tensile strength. As initial approach, it was chosen the polymer PDMS as material model of arterial tissue for the simulations. PDMS is a biomaterial well known for its biocompatibility and its low cost that make it a material used in various biomedical (Bélanger, 2001).

The numerical simulations were carried out based on the finite element method (FEM) which allows high accuracy and precision results. The FEM simulations were developed using two different approaches: fluid flow and structural analysis. For the fluid flow analysis was considered a constant flow of 300 μl/min of glycerin. Whereas the structural simulation, used the pressure obtained previously in the fluid flow analysis and the hyper-elastic properties of the PDMS materials that were determined in experimental tensile test.

RESULTS AND CONCLUSIONS

The results from the numerical simulations are shown in Fig. 1. In Fig. 1(a) we can observed the dynamic pressure simulated in the Fluent module of the Ansys®, and in Fig 1(b) the resultant displacement field in the PDMS model using the hyper-elastic constitutive model of Mooney-Rivlin. The constants of the material constitutive model were obtained by adjusting the numerical curve to the strain-tress curve previously measured during tensile test of PDMS material (Fig. 2).



(a) (b)

Fig. 1 - Numerical simulations of aneurysm model: (a) Dynamic pressure and (b) displacement field.

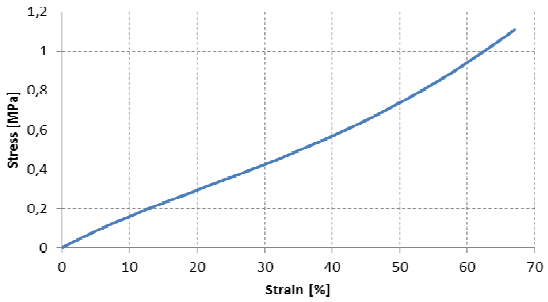


Fig. 2 - Tensile test results of PDMS.

The study shows that there are substantial differences on fluid flow behavior in the channel with and without the aneurysm. In the channel without aneurysm occurred a laminar flow, but with the aneurysm was observed a turbulent flow. The displacement and strain fields were greater in the presence of aneurysms.

REFERENCES

[1]-Branco G, Miguel J, Goulão A, Maurício JC, Diagnóstico Angiográfico dos Aneurismas Intracranianos: Estudo Sobre a Experiência do Serviço de Neurologia do Hospital Egas Moniz, Acta Médica Portuguesa, 1992, 5, p.515-518.

[2]-Masson I, Boutouyrie P, Laurent S, Humphrey JD, Zidi M, Characterization of arterial wall mechanical behavior and stresses from human clinical data, Journal of Biomechanics, 2008, 41(12), p. 2618-2627.

[3]-Bélanger MC, Marois Y., Hemocompatibility, biocompatibility, inflammatory and in vivo studies of primary reference materials low-density polyethylene and polydimethylsiloxane: A review, Journal of Biomedical Materials Research, 2001, 58(5), pg. 467-477.

About the Book:

During the last few decades the development of computer based techniques, as well as new experimental methods, nanotechnologies and nanomaterials, among many other material technological advances, added new dimension and perspectives to mechanical design and manufacturing of engineering systems, structures and components. Different tools are now available to optimize any engineering solution, and we must continue our efforts to develop and use superior materials, apply reliable analytical and numerical techniques and validate these with sound experimental methods.

This volume contains the full versions of papers accepted for presentation in the *M2D2015 - 6th International Conference on Mechanics and Materials in Design* held in Ponta Delgada/Portugal, 26-30 July 2015. This e-book is complemented by an accompanying printed Book of Abstracts containing the extended abstracts of all presentations.

M2D2015 is part of a prestigious series of conferences that was initiated in 1996, in Toronto (Canada), coordinated by the International Scientific Committee on Mechanics and Materials in Design. The conference attracted over 320 participants with 423 accepted submissions from 42 different countries around the world. These papers were presented in July 26-30, 2015 in the magnificent city of Ponta Delgada-Azores, Portugal. The conference themes, which address novel and advanced topics in Mechanics and Materials in Design, focused on analytical and numerical tools at all scales, testing and diagnostics, surface and interface engineering, tribology, mechanical design and prototyping, modes of failure, composite and engineered materials, biomechanics, energy and thermo-fluid systems, impact and crashworthiness and case studies.

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Resumo: This work presents the numerical assessment of the deformation of an artery wall with and without an aneurism. The simulations consider the hyper-elastic behaviour of the artery tissues, taken in consideration the properties of polydimethylsiloxane (PDMS), which are more similar to the biological tissues. The numerical simulations were performed using the commercial finite element routines ANSYS (R), by considering the inner the artery fluid flow and the consequent pressure is used to simulate the wall deformation.

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Palavras-chave de autor: aneurysm model; polydimethylsiloxane; hyper-elasticity; finite element method

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