Creep Assessment in Hyperelastic Material by 3D Neural Network Reconstructor using Bulge Testing

G. Capizzi*, G. La Rosa†, F. Lo Savio†, G. Lo Sciuto°

*Department of Electrical, Electronic Informatic Engineering, University of Catania, Italy
†Department of Industrial Engineering, University of Catania, Italy
°Department of Engineering, Roma Tre University, Italy

Abstract **In this paper is presented a new methodology based on Neural Network which, making use of the Bulge Testing able to reconstruct the three-dimensional dome of the bulge test and also to obtain the membrane stress and strain fields of the material under investigation.**

Keywords **Bulge test, 3D image reconstruction, Neural Netwoks, Hyperelastic Materials.**

I. INTRODUCTION

Modeling the deformation behavior of materials requires first of all its experimental characterization based on simple mechanical tests, e.g., uniaxial tension, equibiaxial tension, pure shear tests and others. These tests are the starting point to propose constitutive equations aiming to describe material response, then to identify material parameters of the adopted constitutive equation.

Bulge test was mostly conducted as an easy way to determine mechanical behavior of isotropic materials subjected to equibiaxial tensile stress state. Indeed, due to the axial symmetry of the problem and respecting the primary assertions of the membrane theory, the equibiaxiality of the stress and strain is obtained at the top of the inflated sample. To achieve this goal the knowledge of the curvature radius, tangential elongation and pressure recorded during the test are needed, so it must be postulated an explicit form of constitutive relationship to represent the material. As a consequence, there is a loss in generality.

In this paper is presented a new methodology based on Neural Network which, making use of the Bulge Testing able to reconstruct the three-dimensional dome of the bulge test and also to obtain the membrane stress and strain fields of the material under investigation.

The experimental results obtained in the bulge test of a neoprene rubber material are presented. These data allow to validate the curvature calculation method and to estimate errors associated with the membrane stress and strain determination.

II. THE PROPOSED METHODOLOGY FOR CREEP ASSESSMENT OF HYPERELASTIC MATERIAL

The selected Feed Forward Back Propagation Neural Networks (FFNNs) have three inputs (The cartesian coordinate (x,y) and the the inflation pressure P), one output (the height z) and is composed by an input layer, an output layer and two hidden layers: the five neurons arranged in the first hidden layer and five neurons arranged in the second hidden layer have tangent sigmoid transfer function, while for the output layer has been used a linear transfer function.

For this FFNN we used a fast Levenberg-Marquardt algorithm, the well known gradient descent with adaptive learning rate back-propagation algorithm and the relative learning parameters. The method used during the implementation of the neural network was to separate a set of available data into three subsets: training, validation and testing sets. The training set is used as the primary set of data that is provided as input to the neural network for learning and adaptation, while the testing set is then used to determine the performance. The performance of the FFNN were evaluated using Mean Square Error (MSE) as metric. The mean square error obtained over the testing set is 0.010593.

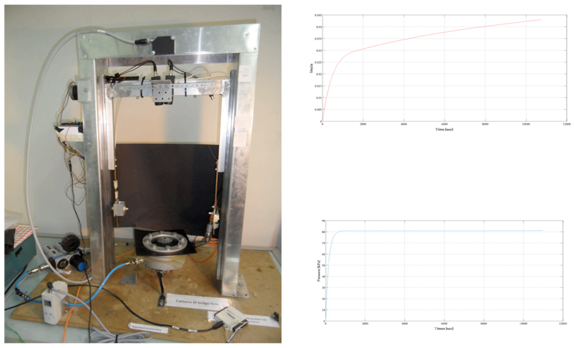

Fig. 1. On the left: experimental system. On the right: traces of strain and pressure

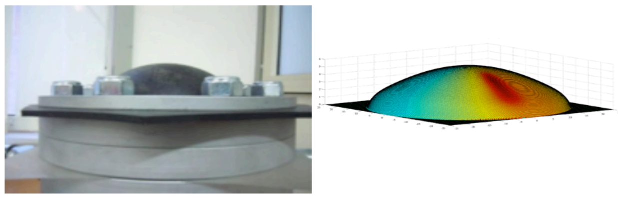

Fig. 2. On the left: A dome experimentally obtained. On the right: neural reconstraction of the dome.

III. EXPERIMENTAL SETUP AND RESULTS

In Fg.1 on the left it is shown the built experimental system for the Bulge Testing while on the right are shown the traces of the measured pressure and of the strain obtained by the neural network. In Fig. 2 on the left is shown an example of a dome experimentally obtained while on the right the neural reconstruction of the dome.

IV. REFERENCES

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