THE USE OF THE DANTEC 3D IMAGE CORRELATION SYSTEM TO DETERMINE DEFORMATIONS AND DISPLACEMENTS

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Abstract

The subject of the work is to present the possibility of using a non-contact optical system for measuring strains. Dantec's multi-unit Q-400 3D image correlation system was used. The aim of the work was to determinate the distribution of displacements and deformations on the surface of samples with different cross-sections and made of different materials during the bending test. The measurement was used basically to estimate the deflection line of the bending beams and at different points of the cross-section. Measurement was carried out by tracing the displacement of the prepared surface of the bending sample. In the paper, the results of the studies show the displacement and deformation fields for different bending steps of flat samples. A numerical model of the bending process was also developed to compare the results with experimental studies.

Keywords: Displacements, 3D image correlation system, bending test

1. INTRODUCTION

The bending test is one of the static methods for determining the strength properties of engineering materials. The conditions of bending test are included in the PN-EN ISO 7438 standard. It can be performed both at room (ambient) temperature and at reduced or elevated temperature. The use of a non-invasive measurement method makes it possible to detect defects more quickly without the need for specialist preparation of test specimens. The advantage of using optical measurement methods of deformation or stress distribution is the ability to identify changes in the surface of the test material at microscale level, this allows early identification of the process before its dynamic development. The digital image correlation method used images of the object taken at the same time by several optical cameras with high sensitivity to deformation and vibration of the object being observed. This method of measurement is currently used increasingly to determine the components of stresses, deformations or displacements in laboratory conditions, and to identify defects in machine construction components under the influence of static loads or dynamic variables over time [1,2]. Measurement methods allow for easier adaptation to the measurement of parts of machine parts in their natural industrial environment under real operating conditions.

2. THE 3D SYSTEM OF IMAGE CORRELATION

The Q-400 system used with the ISTRA 4D software is a multifunctional non-contact tool for measuring the deformation of a tested object in both two- and three-dimensional coordinate systems. The principles of the system are based on relationships existing in the continuous mechanics. Dimensions and positions of the two points in the state before and after the deformation are considered. The correct operation of the system is based on the appropriate lighting and then the analysis of the light beam reflected from the surface of the observed piece before the load and in the subsequent steps of the load for consequence the deformations to appear.

The measurement method is based on the correlation of digital images, recorded with two or more cameras. The surface of the object is covered with a layer of white and black paint. The measurement is done by tracking spots coated surface of the object subjected to load. Using two digital cameras, it is possible to perform 3D analysis [3-5]. When cameras record a test object from different pages, the position of each point of the object is focused on a specific point in the camera matrix. The position of each point of the examined object in a three-dimensional coordinate system can be calculated, when all the parameters are known recording, focal lenses and the position of the cameras are interrelated. In this way, every point of the object's surface, tracked by the camera, can be defined in all planes. Algorithms allow you to correlate the same point on the object plane to test all the cameras. Deformation of the object is determined by the observation of the image recorded by the CCD camera. Correlation algorithms allow for a maximum displacement of up to 1/100 pixel matrix [4].

The correlation algorithm tracks the position of the same points in the source image and the distorted image (**Figure 1**). To achieve this square surface containing a set of pixels, it is identified in the source image and in the position corresponding to the image after the deformation. There are many parameters that affect the accuracy of the results. They concern among other things, the size of the tracked spots, its density, The type of algorithm, the size of the set of points, the overlap of the set of points, etc. [6,7]. Well optimized input parameters allow obtain very accurate results.

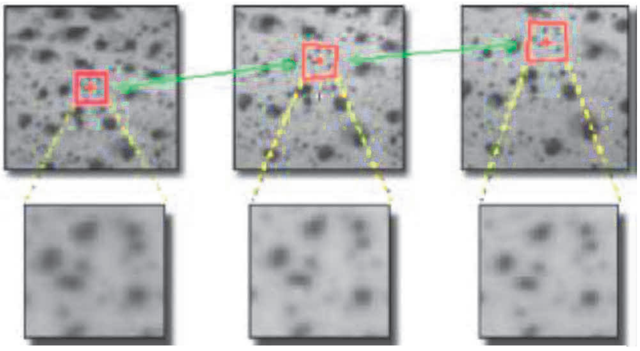

Figure 1 View of the surface [3]

3. THE RESEARCH OF MECHANICAL PHENOMENA

Bending test is one of the basic tests to determine the mechanical properties of materials. The research uses a universal testing machine Zwick & Roell Z100 with maximum load 100kN and precision 1N force / 0.01 mm displacement (without a touch extensometer, **Figure 2**).

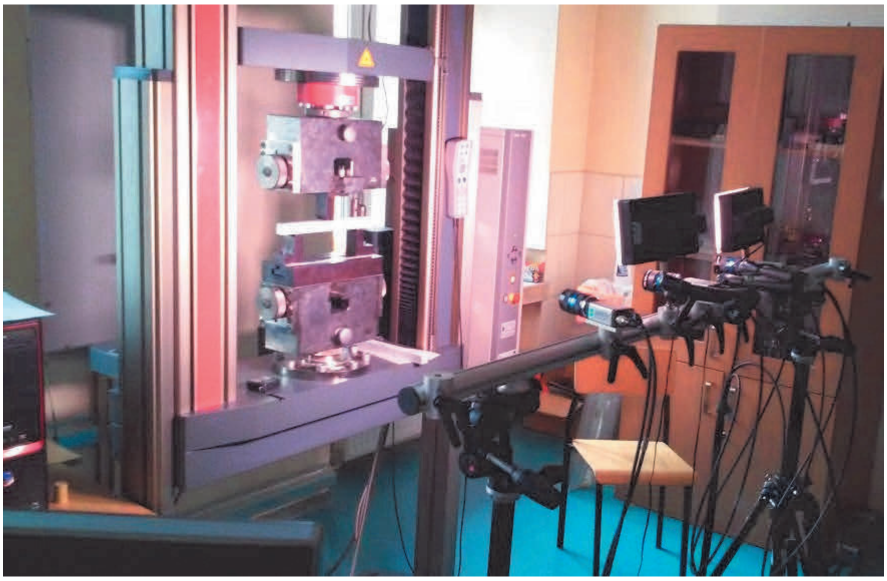

Figure 2 System of measuring

Beam of square section (25mm x 25mm) made of stainless steel 1.4301 loaded in subsequent attempts of forces from 10 kN to 25 kN with increments for every attempt what 5 kN. The Dantec system, during the bending test, took pictures with frequency 10 Hz (0.1 s). The measuring apparatus was set at a distance of about 97 cm from the object under test, **Figures 3 - 6**.

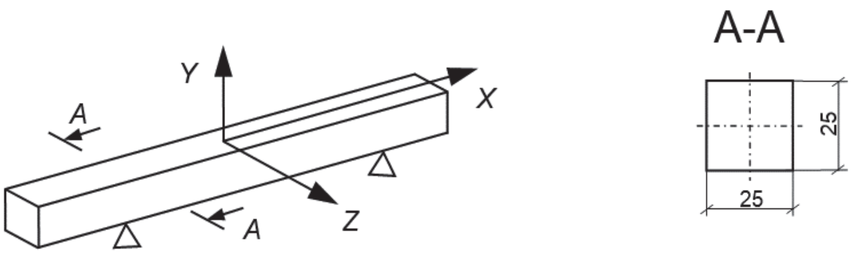

Figure 3 Scheme of considered systems

In strength calculations, patterns based on assumptions are commonly used, although they are rarely practically met. More general bending descriptions are known that do not depart from these assumptions, but the benefits of their practical use are generally small compared to the complexity of the calculations they cause [8]. Flexural strength is a conventional quantity. It can be treated as a comparative quantity for the evaluation of different materials.

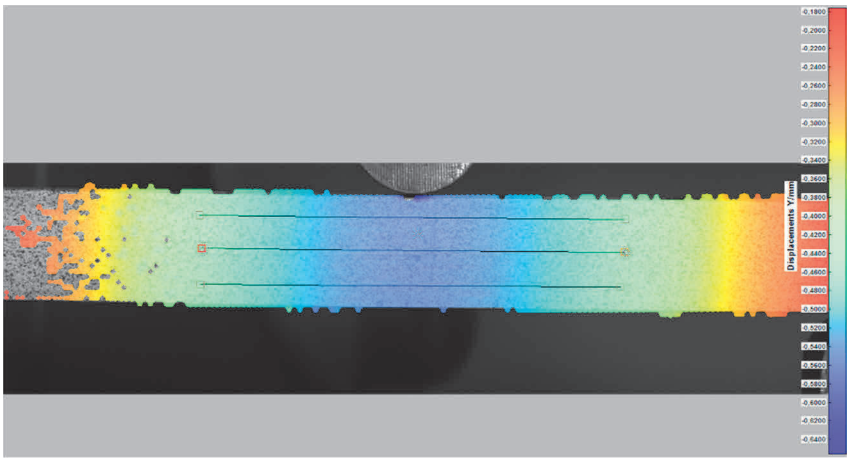

Figure 4 Square beam 25 mm x 25 mm stainless steel 1.4301

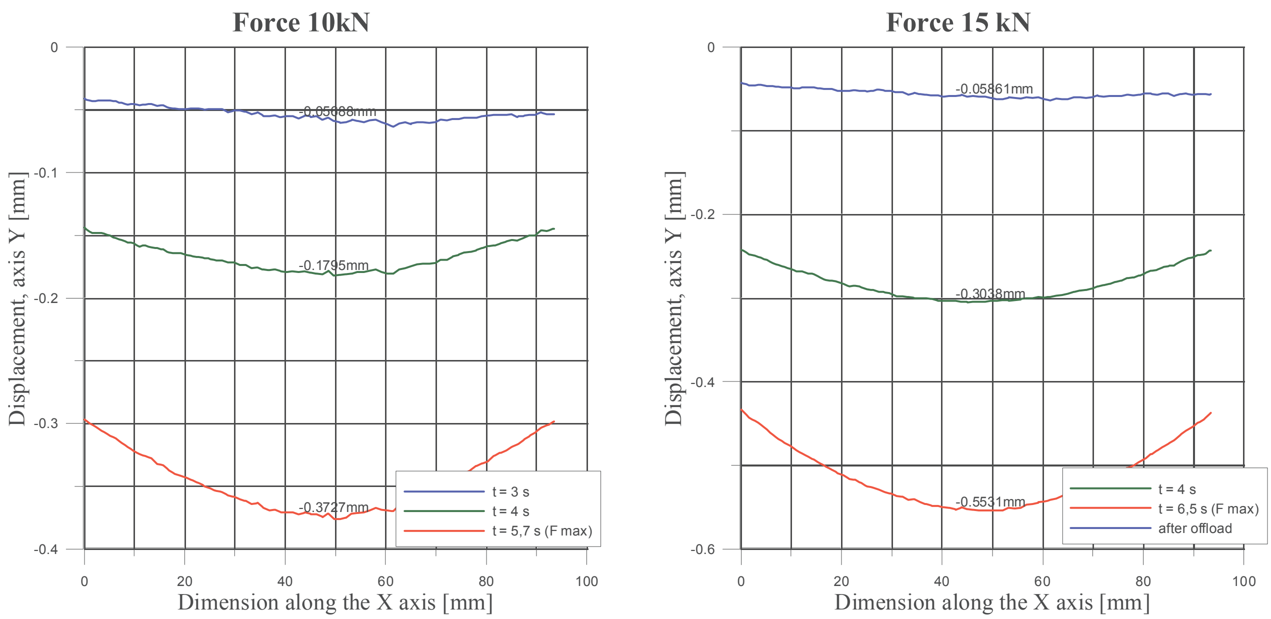

Figure 5 Displacements distributions along the axis X

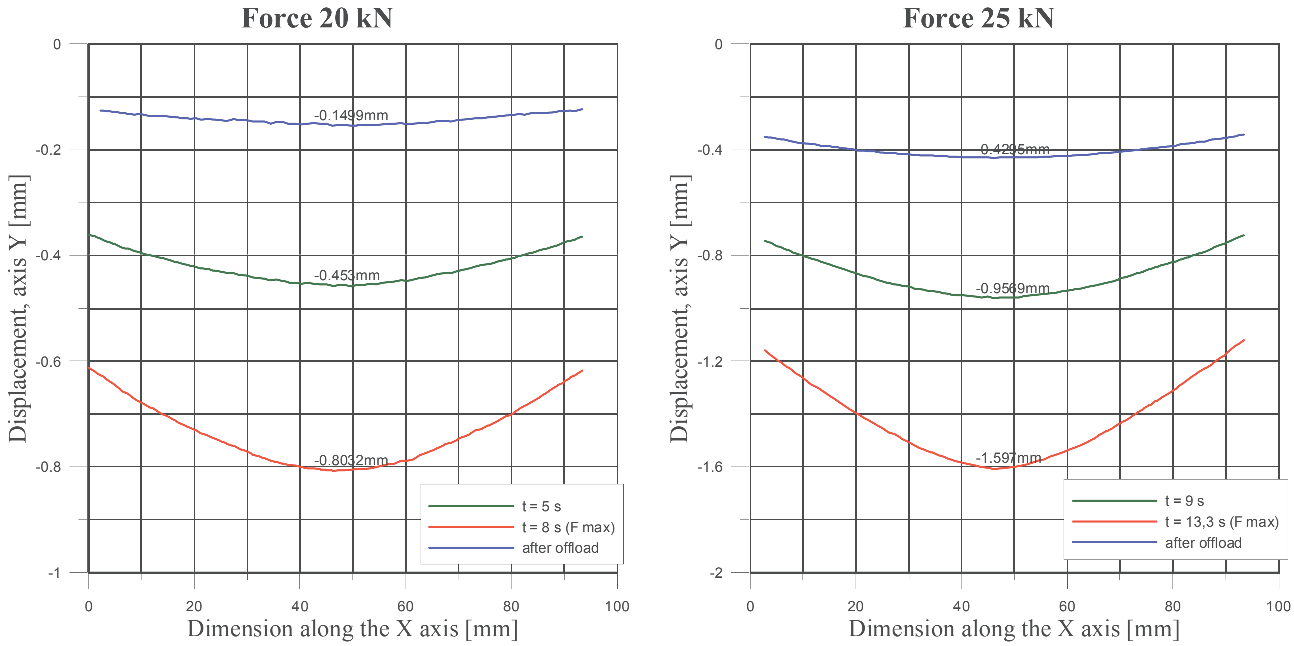

Figure 6 Displacements distributions along the axis X

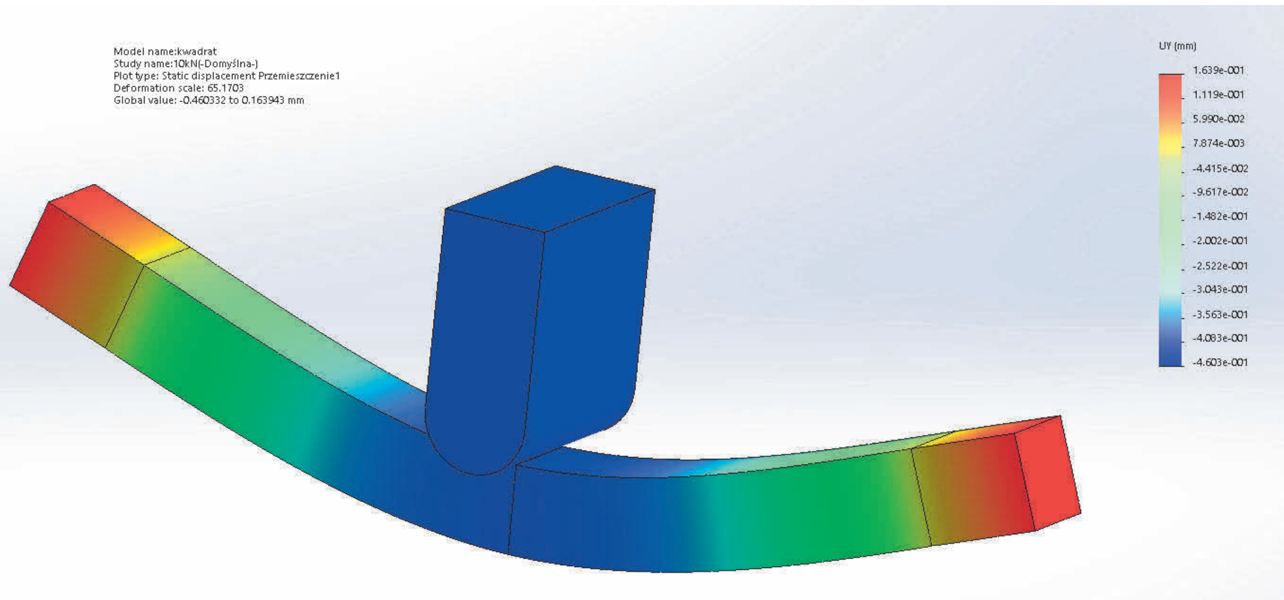

Figure 7 The results of numerical simulation (displacement U_y)

A numerical simulation of the bending process was carried out, the results of which are shown in **Figure 7**. The maximum values of displacements in nodes were determined at various stages of the loading process, and the results are presented in **Table** 1.

The distributions of displacement U_y in a bending sample of the material shows **Figures 5 - 6**. Marked on the image line corresponds to a central axis of the sample, wherein the graphs are compared displacements for the different forces carried out. Comparison of distributions displacement U_y for the 10, 15, 20, 25 forces [kN] and at the on three different measuring lines is shown below **Figures 4 - 6**.

Table 1 Comparison of results for bending the beam

	Force [kN]	Dantec systems	SolidWorks	Analitycal method
Displacement [mm]	**10**	0.3727	0.4601	0.4424
	15	0.5531	0.6902	0.636
	20	0.8032	0.9203	0.8847
	25	1.597	1.150	1.106

4. CONCLUSION

After analyzing the results, a fairly large convergence of results is noticed. The values of displacements received from the experience carried out using the Dantec system are burdened with the biggest error. This may be caused by too low a frequency of making a relic during the measurement process. The results obtained from analytical calculations are very similar to those from numerical simulation.

The use of the 3D optical correlation system allowed the analysis of displacements and deformations on the whole surface of the sample and in the control area of the measurement or on the measuring section. The use of the system allowed for the analysis of deformation during bending test. The obtained results can be very helpful in the experimental verification of mathematical models and numerical mechanical phenomena in which deformation occurs.

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