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# MEASUREMENT OF THE EFFECT OF BI-AXIAL STRESS ON THE BARKHAUSEN NOISE

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## Abstract

Mechanical stress has a strong effect on the magnitude of the Barkhausen noise in structural steels. Because the easurements are performed at the surface of the material, for a sample sheet, the full effect can be described by a biaxial stress field [1,2]. The measured Barkhausen noise is dependent on the orientation of the exciting magnetic field relative to the axis of the stress tensor. The sample inhomogenities including the residual stress also modifies the angular dependence of the measured Barkhausen noise.

We have developed a laboratory device with a cross like specimen for bi-axial bending [3]. The measuring head allowed performing excitations in two orthogonal directions. We could excite the two directions independently or simultaneously with different amplitudes. The simultaneous excitation of the two coils could be performed in phase or with a 90 degree phase shift. In principle this allows to measure the Barkhausen noise at an arbitrary direction without moving the head, or to measure the Barkhausen noise induced by a rotating magnetic field if a linear superposition of the two fields can be assumed.

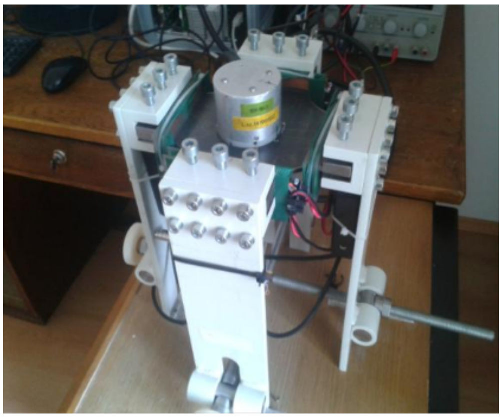

Figure 1: Bi-axial bending measuring equipment

## I. Introduction

Mechanical stress has a strong effect on the magnitude of the Barkhausen noise (BHN) in structural steels. Because the measurements are performed at the surface of the material, for a sample sheet, the full effect can be described by a biaxial stress field [1,2]. The measured Barkhausen noise is dependent on the orientation of the exciting magnetic field relative to the axis of the stress tensor. The sample inhomogenities including the residual stress also modifies the angular dependence of the measured Barkhausen noise. With our measuring system we can describe the stress state in different points of the sample. To get better results we applied different techniques on the same sample to calculate the stress state of the same points. In this article you can read the results.

## II. Barkhausen Noise Measuring

### *II. A. BHN measuring*

We have developed a laboratory device with a cross like specimen for bi-axial bending [3]. The measuring head allowed performing excitations in two orthogonal directions. We could excite the two directions independently or simultaneously with different amplitudes. The simultaneous excitation of the two coils could be performed in phase or with a 90 degree phase shift. In

principle this allows to measure the Barkhausen noise at an arbitrary direction without moving the head, or to measure the Barkhausen noise induced by a rotating magnetic field if a linear superposition of the two fields can be assumed.
On the lower side of the cross shaped sample a biaxial strain gauge was installed. Strain gauges are also installed on the driving screw actuators. We have measured the actual deformations of the sample surface using a grid and an optical measuring system.
[3]After we created the measuring head and we have the method how to measure the stresses in different formed zones, and rotate the magnetic field by software. We had to create measuring software which handles the data and all the input to get the most accurate results. The basic requirements of the software:

1. Dynamic instrument control and signal display
2. Automated measurement sequences
3. Data storage, presentation
4. Noise measure evaluation and comparison

### *II.B. [3]Dynamic instrument control*

We were built a hardware from different modules which handles different tasks. To combine and control the data inputs for different tasks eg. bending moment of the sheet metal specimen, amplified noise handling, air gap, and voltage and sign control.

### *II.C. [3]Automated measurement sequences*

Measuring and combining different parameters needs different and parallel controlled measuring methods. To control these tasks we have to create different automated sequences to get the best results. On the Fig.2 can seen the control panel for this process.

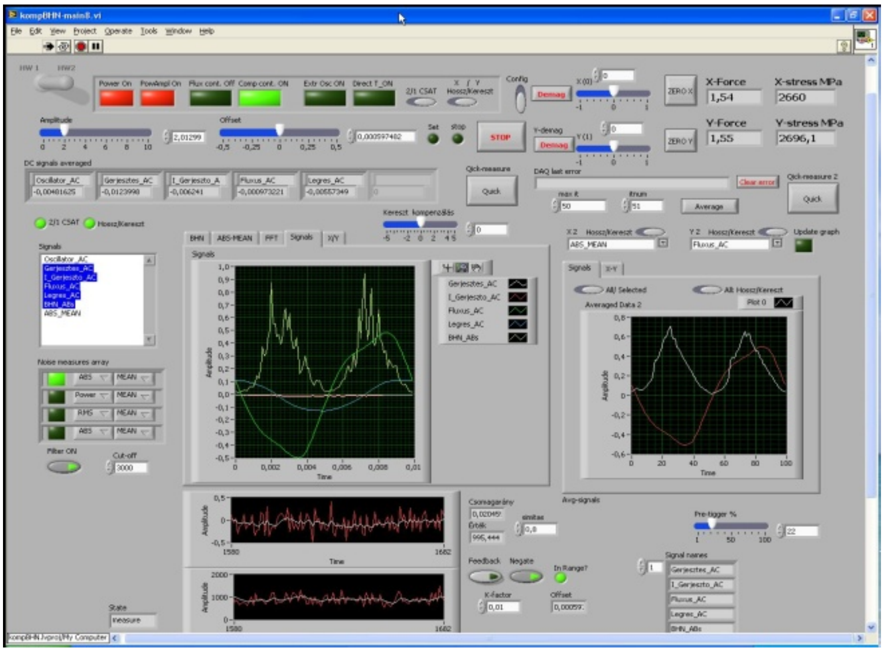

Figure 2: Control panel[3]

### *II.D. [3]Data storage, presentation*

Certainly if we measured with combined process we have to handle and save these data to the future use. We also made a data handler part. This part of the software can seen in Fig.3

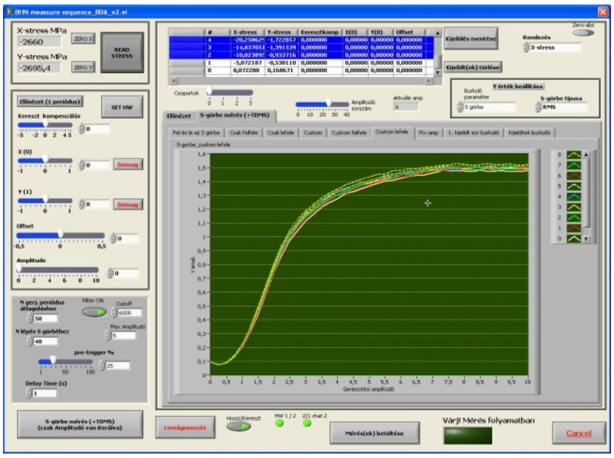

Figure 3: Data handle&storage [3]

### *II.E. [3]Noise measure evaluation and comparison*

When we made the measuring we can indicate the stress depencities from the mechanical stress with the last module. This module can seen on the Fig.4.

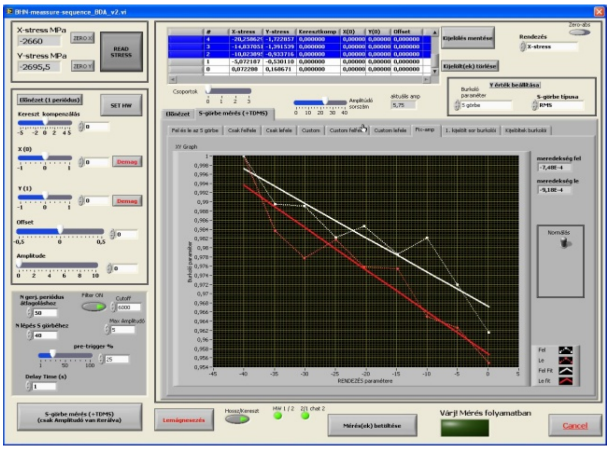

Figure 4: Noise measure evaluation and comparison[3]

## III. Optical Measuring Method

Figure 5: VIALUX system & bi-axial stress measuring

Measuring the yield we used the VIALUX optical measuring system(Fig.5). This system works with five CCD camera and we can use different resolution grids to measure the yield on the surface of the test sample. There are two way of grid creation. We can create the grid on the sample surface by paint or we can use a pre-created grid on a foil. This foil is able to yield near two hundred percent. This system is usually applied in deep drawing of sheet metal parts, especially in automotive industry. On the next figure (Fig6.) you can see an example of the usual task for this system.

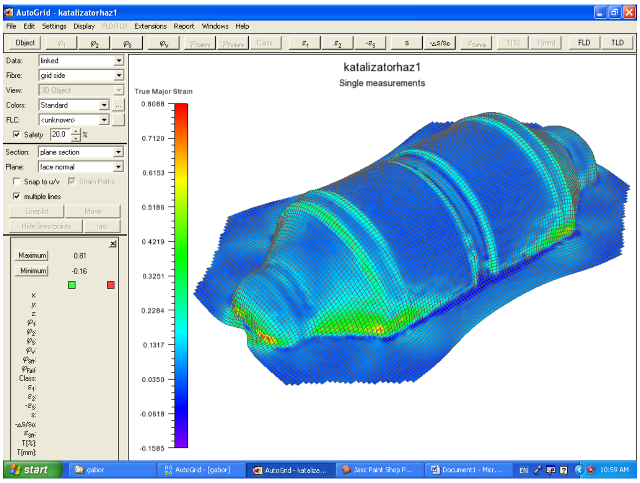


Figure 6: VIALUX system measuring an automotive part

On our sample the maximal bending stress is 50MPa to keep the sample part in elastic deformation zone. Before we can measure the sample we have to calibrate the VIALUX system (Fig7.) with a special tool.

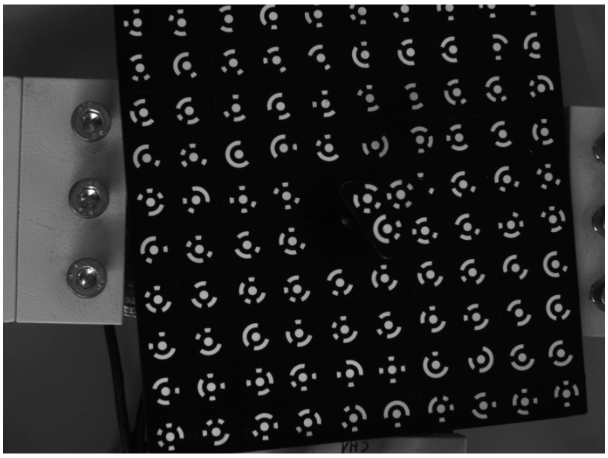

Figure 7: VIALUX system calibration

After the calibration process we can apply the stresses on the sample by our bi-axial measuring equipment. Because of the small yields (we are in the elastic deformation zone) we measured the start sate (zero stress-state on Fig8.) and the maximal allowed deformation at 50MPa in X;Y directions(Fig9-10), and after that we've applied 50MPa on both axis(Fig11).

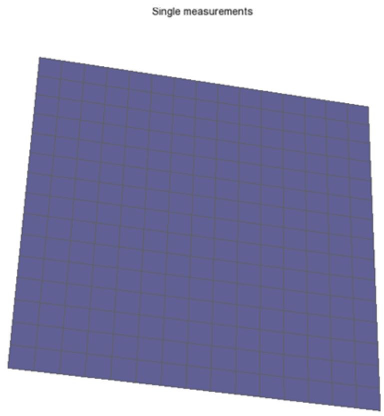


Figure 8: Zero-stress state

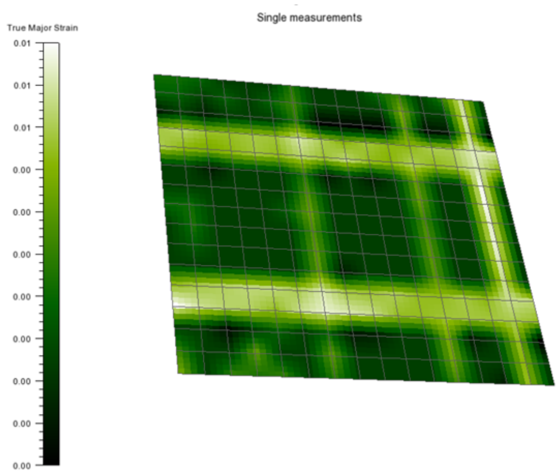


Figure 9: X-direction 50MPa tensile stress applied

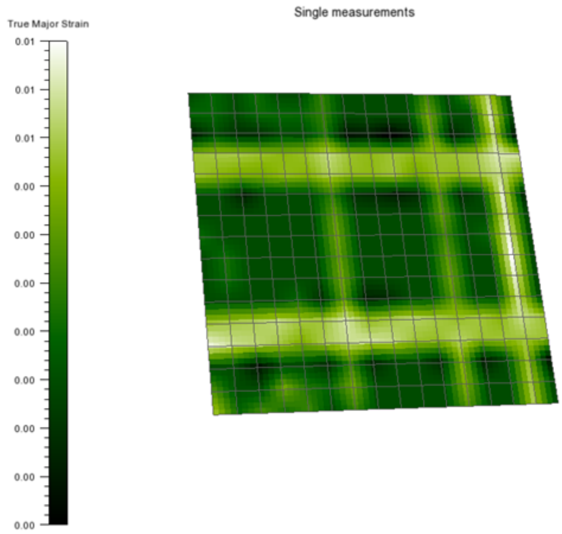


Figure 10: Y-direction 50MPa tensile stress applied

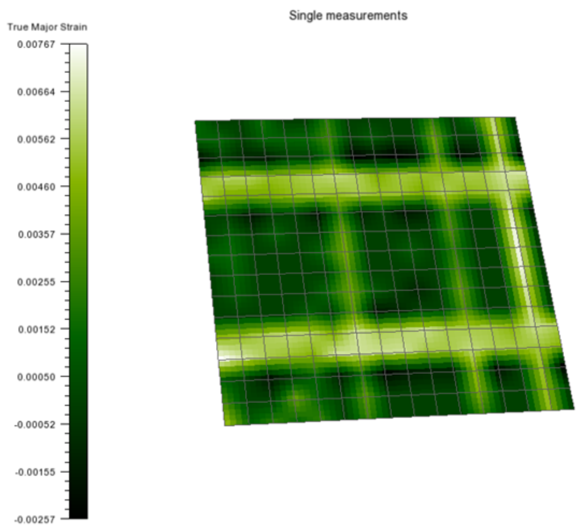


Figure 1: X-Y direction 50MPa bi-axial tensile stress applied

The results of the optical measuring stored in a datasheet, to every grid point, for further use, or we can load, and manage the results in the VIALUX software. These results are yield data, so if we want to get stress data, we can use the Hook-law to calculate back to stresses.

### IV. FEM Simulation

Nowadays we are able to follow the stress state of the formed material in every point during the forming with FEM based simulation system. We can calculate the stresses more accurate than ever. We used the AutoForm system (at the University of Miskolc) to calculate the stresses during forming the sheet metal.

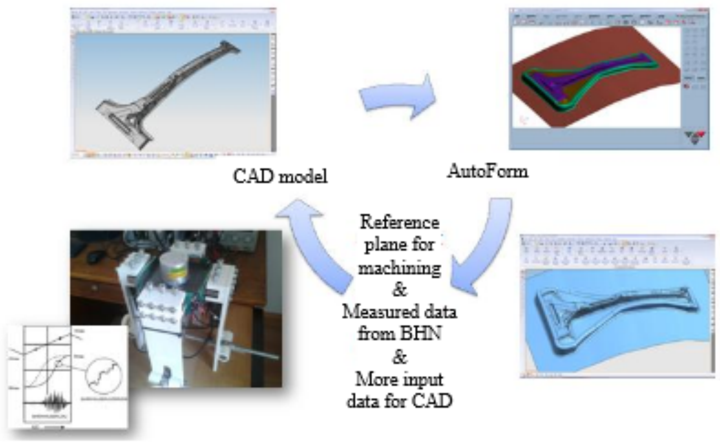


Figure 12: New process circle to combine FEM&BHN[3]

## V. Results

We've made an experimental tests to get result of two directional changing of the stress. The stress values were changed from 0MPa to 50MPa by 10Mpa steps in each direction (X-Y). You can follow the stress ellipse changing on the middle point of the sample on Fig12. in each step. We measured the same effect in notable points of the grid. The point were in order: middle point of the sample, four end corner of the grid (the end points of the diagonal of the grid)

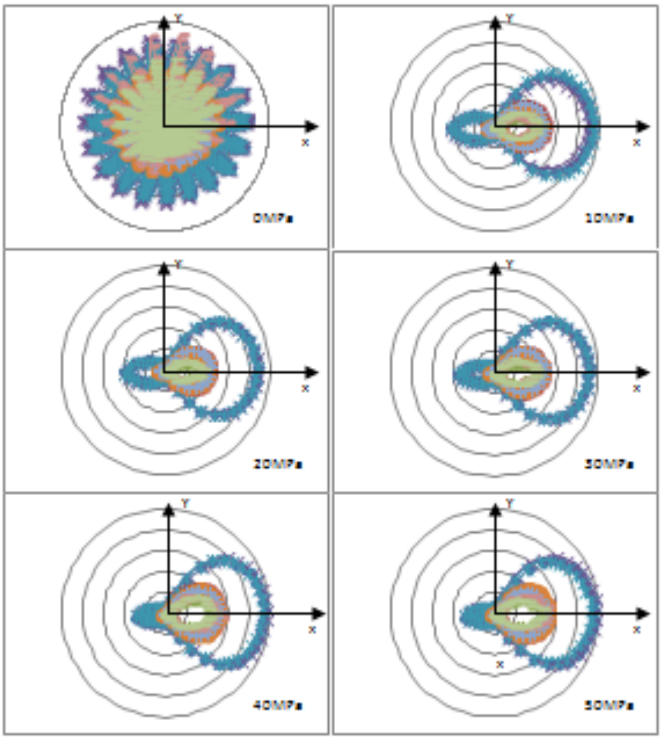


Figure 13: Distortions of stress ellipse in a specified grid point caused by bi-axial stress changing

**Acknowledgment**

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