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Strain Gauge Measurement on Clinched Joints Specimens

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Abstract. This paper describes the preparation, implementation and execution of experimental measurement on clinched joint specimens using strain gauges. The real behavior of the clinched joint specimen during the specified loading was obtained. The results from the experiment were compared with the FE simulations. The designed testing method was further used for testing of more complex specimens.

Introduction

Experimental measurements using different sensors are important in these days because they provide the information about the real conditions and behavior of various components or machines. This information is often one of the basis for subsequent optimizations or validation of computational simulations and analysis, [4], [5].

Clinching represents one of the modern methods for the joining of the sheet metal plates used in many branches of production. The joining method is based on the plastic deformation of the base material and is characterized with many advantages. The creation of the round clinched joint is shown in figure 1.

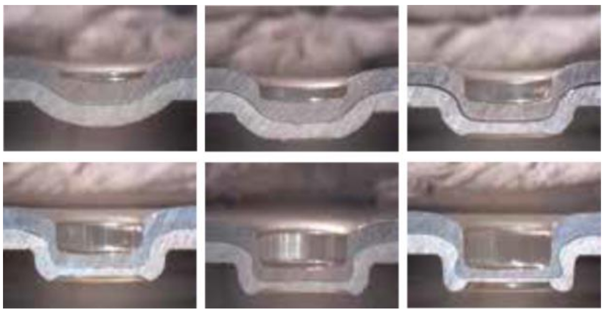

Fig. 1: Creation of the round clinched joint, [2].

Method

The experimental testing of the specimens is described by the unidirectional nondestructive test when the uniaxial stress near the joint is measured using strain gauge during the loading, [1].

Instrumentation and measurement protocol. Special testing stand was designed and built for the realization of the measurement, the scheme is shown in figure 2. The loading is applied by a hydraulic cylinder (HM), velocity of loading is controlled by proportional valve (PV) and the size is measured by HBM force sensor. The controlled variable is force that smoothly increases from 70 N to the maximum value and decreases back to the minimum value.

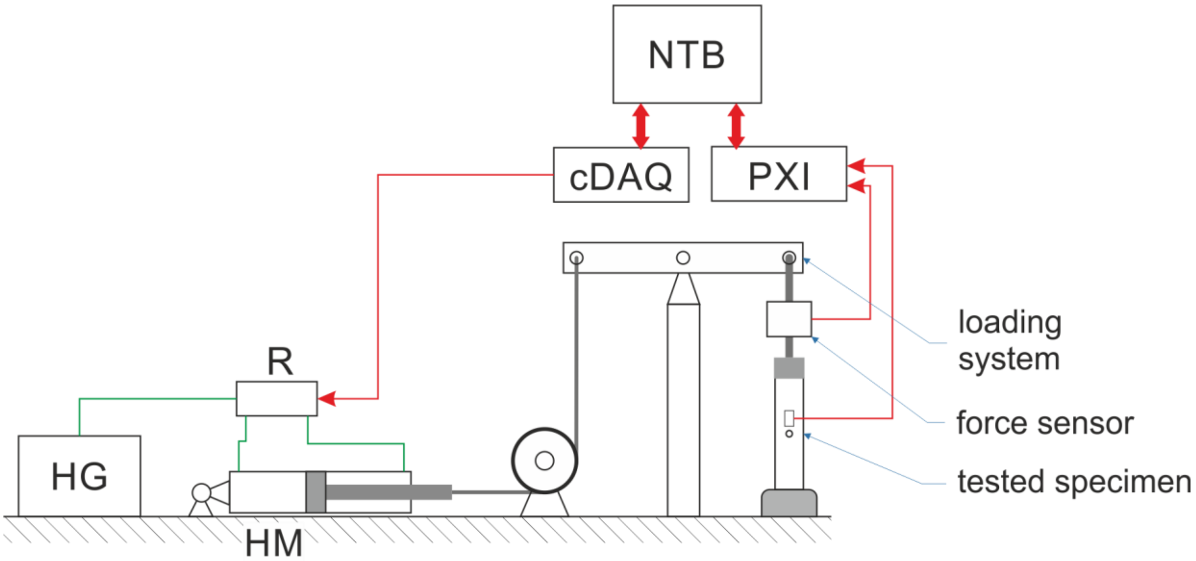

Fig. 2: Scheme of the testing stand

Investigated set of specimens. The specimen for the initial measurement and verification of the method was a connection of two overlapped sheet-metal plates from low carbon steel (1.0226) joint by the single clinched joint, [2]. The deformation in the place of interest was supposed to be uniaxial, therefore the HBM uniaxial wire strain gauge in quarter-bridge configuration was used for the measurement. Placement of the strain gauge on the specimen near the clinched joint is shown in figure 3.

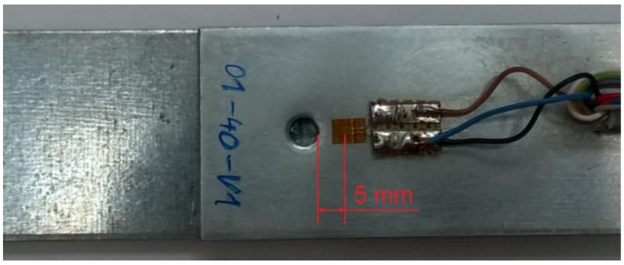

Fig. 3: Strain gauge placement near the joint

Data acquisition and processing. The testing stand is controlled and the data are measured with National Instruments apparatus (cDAQ, PXI) and LabView software. Following data processing is carried out in Matlab. Example of measured data, i.e. loading force and output from the strain gauge converted to the stress, is shown in figure 4. It is obvious from the graph that the total testing sequence consists of three consecutive cycles.

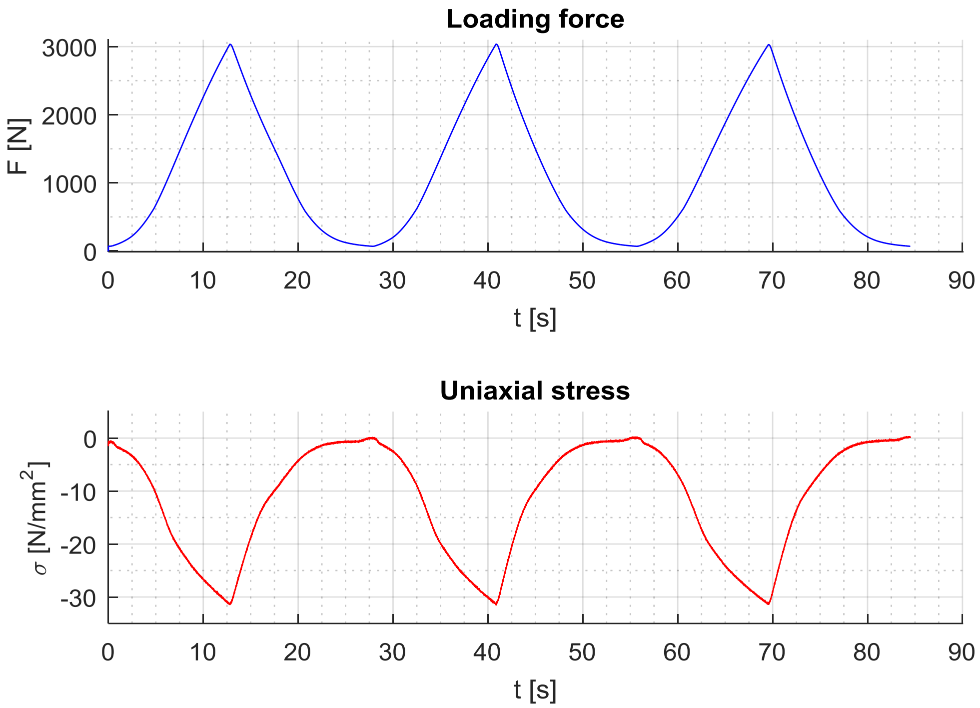

Fig. 4: Measured data

Processing of the measured data represents the identification of the loading force and the dependency between the measured data (loading force and uniaxial stress) as is shown in figure 5. Each cycle consists of loading and unloading part that can be described by the tangent in the linear part of the force course (defined velocity of loading and unloading). The velocities were chosen so that the loading and unloading of the specimen was quasi-static.

The dependency of the measured stress on the loading is plotted in the graph for evaluation of the experiment. The course of the stress depending on the force is different for loading and unloading. This fact can be described by the influence of the testing stand properties, or by the additional bending load of the specimen.

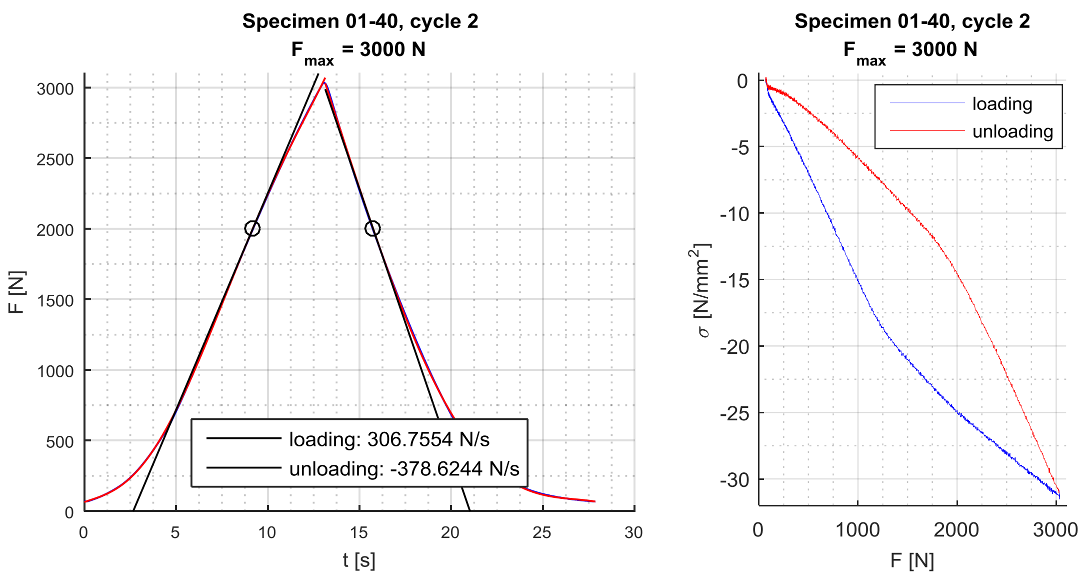

Fig. 5: Processed data

FE simulations

The simulations of clinched joint loading were performed in the engineering software Abaqus CAE using 3D model of the clinched joint, [3]. The uniaxial stress near the clinched joint in the place of the strain gauge (figure 6) was used for evaluation of the simulations and comparison with the experiment.

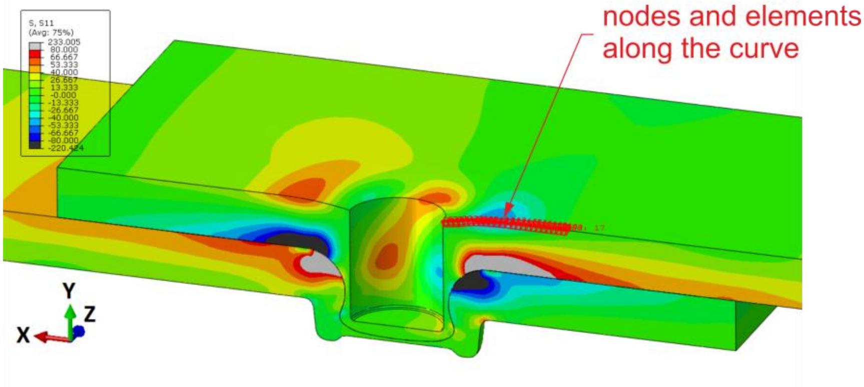

Fig. 6: FEA of the clinched joint model

Results and conclusions

The experimental method of nondestructive clinched joint loading with concurrent measurement of uniaxial stress provides the information about the behavior and properties of the joint. Moreover, the results of FE simulations were used for experiment assessment and mutual comparison. The uniaxial stress from FE simulations in the place of the strain gauge for the loading force of the 3000 N is in the range of -28 N/mm² to -32 N/mm² depending on the conditions of simulations. The measured stress is -29,5±2,6 N/mm² which implies that the experimental measurement and simulations correspond. Next step of the testing was the application of the method on the specimens with three joints in the row varying in the pitch.

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