Experimentální Analýza Napětí 2011
Experimental Stress Analysis

Measurement of Properties of a Sandwich Material Specimen

Aleš Lufinka[1], Petr Horník[2]

Abstract: The sandwich specimen is composed of plastic material carrier and a few deposited metal layers. To measure its real properties was necessary for setting mathematical model parameters and verifying calculated results. A three-point bending approach has been chosen as a comparative method. Particularly detection of the top chrome layer rupture was emphasized. Optical and acoustic methods were used for this detection.

Keywords: Sandwich material, Mathematical model, Measurement

1. Introduction

Sandwich material consists of a plastic core and a few metal layers which are subsequently applied on a plastic surface. The individual layers consist of copper and nickel and the top layer is chrome. This material is used to produce various parts e.g. in automotive industry. The material composition and an example of a product – a trim frame of a car radiator grill can be seen in the Fig. 1.

Fig. 1. Sandwich material structure and a product example

For the purposes of simulation computations (in the PAM-CRASH software) of a front car bumper dynamic loading according to the regulation ECE 42 it is necessary to prepare a material model for the electroplated part which is part of the front car bumper assembly. As the sandwich material model is not simple it was decided to verify its validity by comparison with the real material test. One of the test requirements was detection of the chrome rupture point.

[1] *Ing. Aleš Lufinka, Ph.D.; Technical University of Liberec; Studentská 2, 46117 Liberec, Czech republic; ales.lufinka@tul.cz*
[2] *Ing. Petr Horník; Technical University of Liberec; Studentská 2, 46117 Liberec, Czech republic; petr.hornik@tul.cz*

2. Method of verification

For the purposes of comparison of the material model with reality, a few specimens were cut from the real product. The sampling areas were selected so that the specimens had preferably straight shapes. From the 3D model a simplified shell in the software PAM-CRASH was created. The real specimen and its 3D model are in the Fig. 2. Properties corresponding to various material layers were defined for this model. The specified thicknesses of metal layers were set-up according to the producer data sheets.

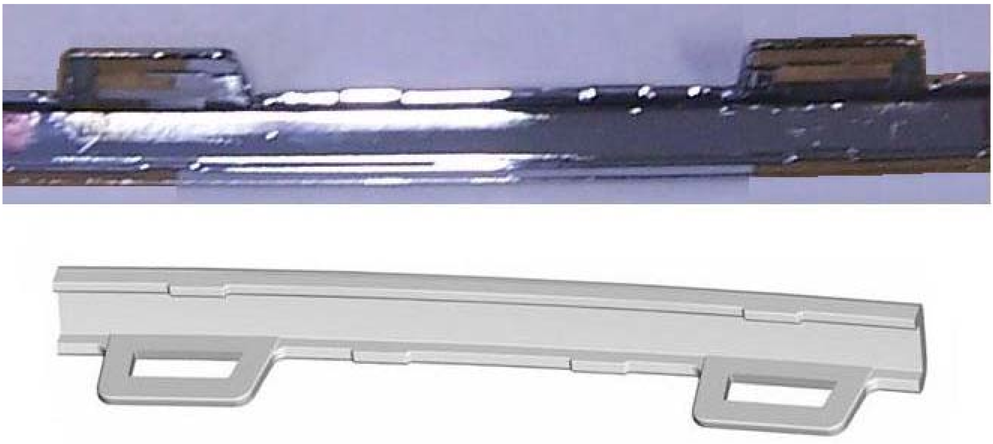

Fig. 2. Real specimen and its 3D model

To verify validity of the simulation, a simple type of test had been chosen – classic three-point bending test. The simulation was performed in the software PAM-CRASH. The loading velocity of 100 mm/s had been chosen so that dynamic behaviour of the model could be examined. The real test execution and simulation model of the three-point bending test can be seen in the Fig. 3.

Fig. 3. Three-point bending test - simulation and reality

For the comparison of the simulation and the real test, loading-deflection dependence had been chosen. The real test should also detect an instant of crack initiation in the metal layer of the specimen.

3. Measuring device

Relation between the force and deflection describes the basic nature of the specimen. Recording of these values is rather a simple standard measuring task. Deflection was measured by a position sensor inside the linear hydraulic engine and the force by a standard strain-gauge dynamometer (force sensor). A larger problem was the detection of the top chrome layer rupture. Testing of various detection methods was impossible as only a limited number of specimens was available. Therefor two parallel detection methods were used – optical and acoustic. The surface of the specimen was monitored by a high speed camera and the sound during the rupture was scanned by a unidirectional microphone. Power spectral density was evaluated from the sound channel in real time too. All analogue channels and the video signal from the camera were recorded synchronously by a data logger. As the loading speed was 100 mm per second, the sampling rate of the analogue channels was set to 25 kHz and the camera speed was 1000 pictures per second (the camera maximum adjustment). Considering the high speed of the camera scanning, the surface of the specimen had to be sufficiently lighted. Two LED lamps were used for this lighting to prevent the specimen warming-up. Orientation of the lamps and the camera lens opening set-up are very important for the correct video recording because the specimen surface is very glossy. The schema of the measuring task and its real execution are in the Fig. 4.

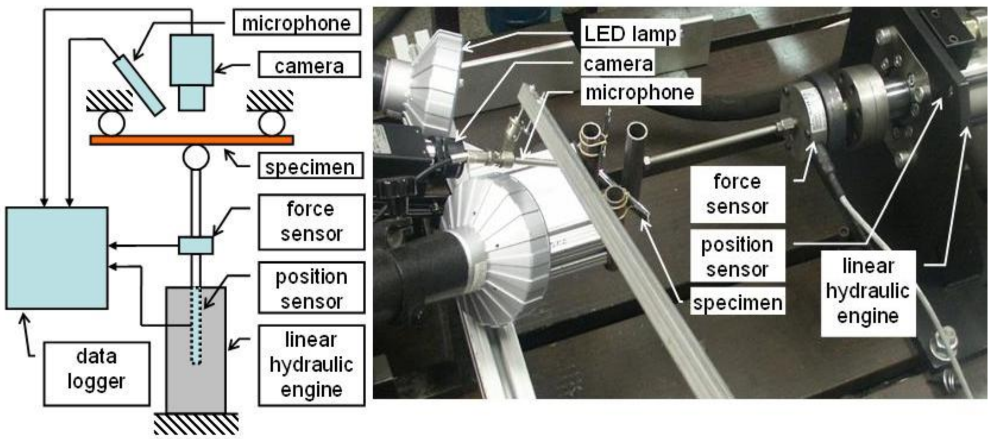

Fig. 4. Schema of the measuring task and its real execution

4. Results

Data analysis showed that the crack propagation in the chrome layer is evident from the force-time recording. Step change (or series of step changes) of the force curve is caused by the crack. The crack initiation and propagation are very clearly visible on the video recording, which positively corresponds to the force-time curve. To obtain the clear video-recording, it was crucial to direct the light very carefully so that the crack was clearly visible on the glossy specimen surface. It also appeared that the acoustic detection of the crack was not reliable. The signal amplitude and some frequency levels increased during the crack, but definite relation between the crack and the acoustic recording was not proved.

Measured relations between the force and deflection were compared with the results of the computational model. An example of such a comparison is in the Fig. 5. On the right side there are several shots from the video recording where the crack initiation and propagation are apparent - corresponding to the marked part on the measured force curve.

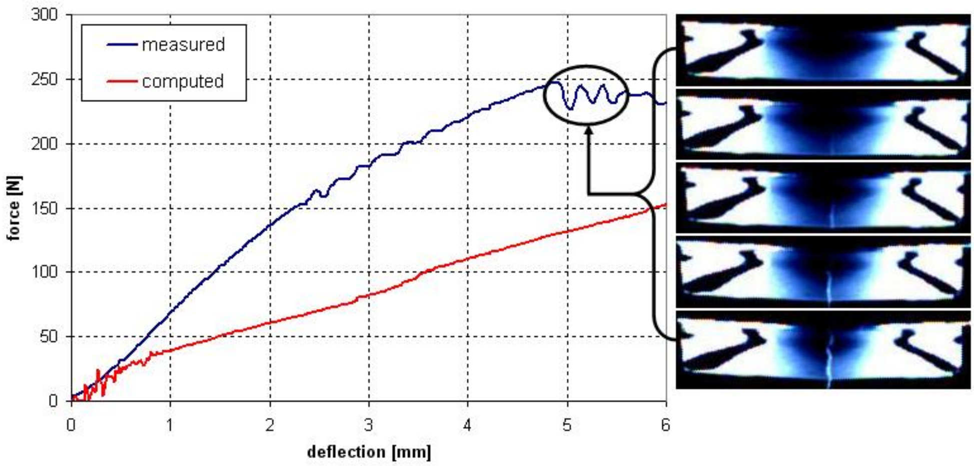

Fig. 5. Comparison of measured data and computed result

Comparison of the dependencies showed that the material model has different mechanical properties than the real specimens. The specimens were subsequently gauged and it occurred that the total thickness of the metal layers does not correspond to the exact value declared by the producer. The material model differed from the real specimens because it was created according to the value declared by the manufacturer. The actual thickness of the layers was larger, which corresponds to the larger force on real specimens in comparison with the material model. Another reason could be a simplified shape of the material model in comparison with reality.

5. Conclusion

The chosen method of synchronous data and video recording appeared as very useful for identifying the crack initiation and propagation in metal layers of specimens. For correct function of the material model it is necessary to accurately determine thicknesses of individual metal layers. Therefore it was decided to make a new set of specimens of simple shapes where the thicknesses of individual metal layers will be accurately measured. These values will then be used in the material model. The results will be again compared with the real measurement.