Advanced Materials Research Vols. 931-932 (2014) pp 317-321
Online available since 2014/May/09 at www.scientific.net

doi:10.4028/www.scientific.net/AMR.931-932.317

Application of Using the Optical Strain Measuring Device in Material Testing and Tools and Dies Design

K.Sirivedin[1, a *]

[1]Materials and Production Engineering, The Sirindhorn International Thai-German Graduate school of Engineering (TGGS), King Mongkut's University of Technology North Bangkok (KMUTNB), Bangkok, Thailand.

[*a]kumpanat.s.mme@tggs-bangkok.org

Keywords: material testing, strain measurement, AutoGrid® Compact, FLD, U-bending test, tools and dies design and tryout

Abstract. Optical strain analysis system plays an important role in tools and dies design, particularly in the phase of die design and die tryout. The objective of this paper is to present the information of the application by using the optical strain measurement device in tools and dies design and material testing. Therefore, two cases in mechanical testing and one case of tools and dies design are demonstrated. The AutoGrid® Compact strain measuring device is applied for all cases. The determination of Forming Limit Diagram (FLD) by using tensile testing machine and U-bending test supported by the optical strain measuring technique is performed and illustrated. In this paper, the procedure of material testing is developed and applied from related literatures. The result obtained from several cases shows the powerful performance of using the strain measurement device for providing the strain information in each situation of forming material as required so that the engineer can tackle the problem and find the solution to improve the production processes in a short time.

Introduction

This paper will demonstrate the three ideas regarding the application of the strain measurement device (AutoGrid® Compact System) for collecting the strain information in material testing and tools and dies design and tryout. The first idea involves the determination of FLD. In the past, to determine the strain distribution on sheet metal stamping and material testing was time consumable, especially the determination of Forming Limit Diagram (FLD) that used for evaluating the formability of sheet metal. The concept of FLD introduced by Keeler and Goodwin [1-2] was represented by the relationship between major strain and minor strain on sheet metal surfaces at the onset of localized necking under the linear strain path assumption [3-4]. The second idea concentrates on the U-bending testing of sheet metal. The U-bending dies is designed and constructed according to the Benchmark of NUMISHEET 2011. The result obtained from this test shows the springback effect related to the springback factor (K) and ratio of radius after springback per thickness (r_i/t). In addition, the strain distribution on the critical area is measured and represented.

The third idea illustrates the implementation of the strain measurement device in tools and dies design and tryout. The Autogrid® strain analysis system is introduced to evaluate strains of a stamped part during die tryout. Furthermore, the applications of the Autogrid® system is presented so as to demonstrate the advantages of using this strain analysis system. As a result, the Autogrid® provide beneficial information in term of tools and dies engineering analysis and quality inspection.

Experiment procedure

The AutoGrid® Compact System is used to directly measure the strain distribution during the test. Fig. 1 shows the schematic of strain measurement. Therefore, the preparation of the good quality of square grid on the sheet specimen plays more important role. Fig. 2 shows the electro-chemical etching technic which is applied for this purpose.

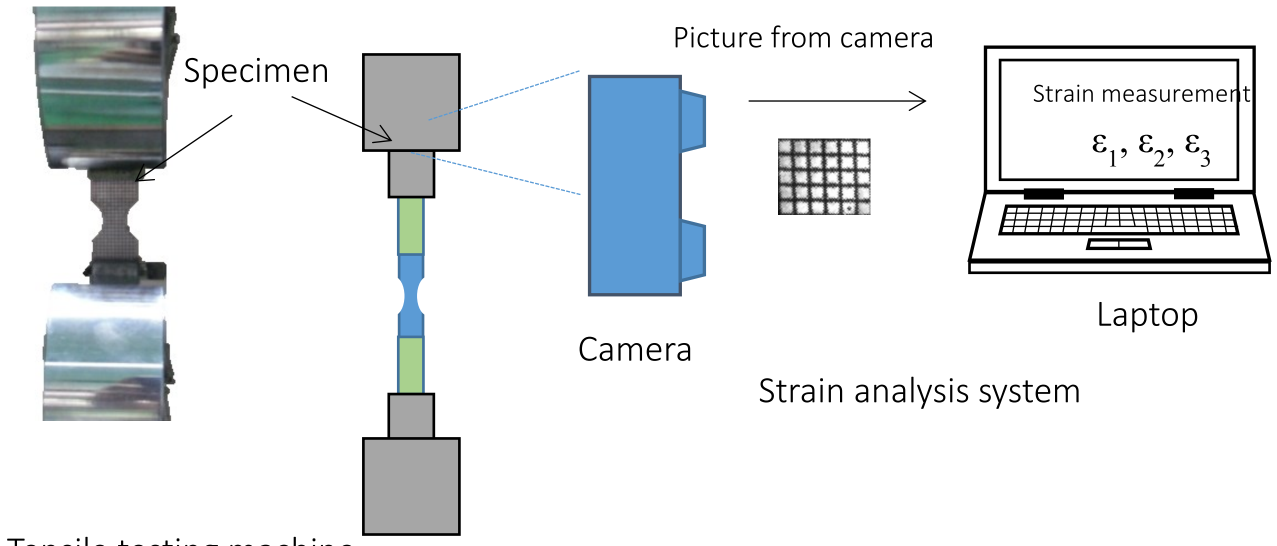

Figure 1 Schematic of strain measurement system applied on the FLD determination

Fig. 1 represents the schematic idea for setting up strain measurement system on the experiment. However, the preparation of the high quality of square grid pattern on the surface of sheet specimen is regarded the most crucial issue.

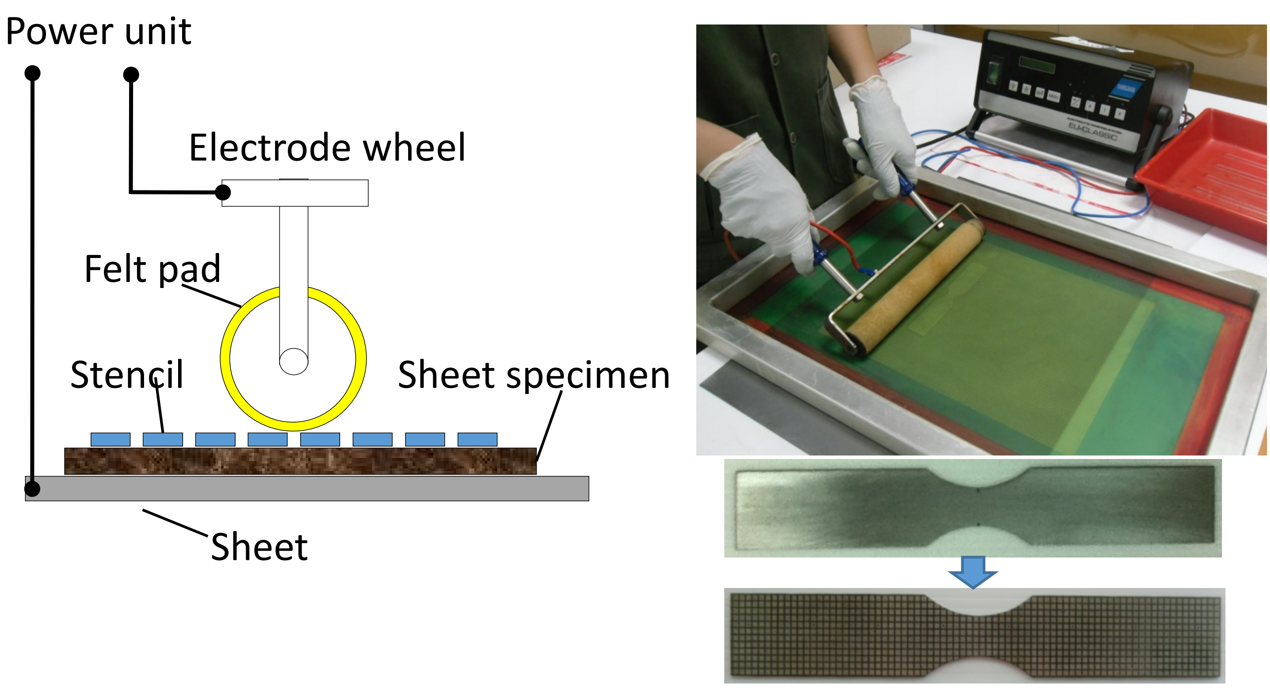

Figure 2 The making of square grid pattern on the sheet specimen

Fig. 1 and Fig. 2 illustrate the basic requirement for using the strain measurement device for all of the three ideas. Figure 3 demonstrates the U-bending dies used for the evaluation of springback and bending force that is directly installed into the tensile testing machine.

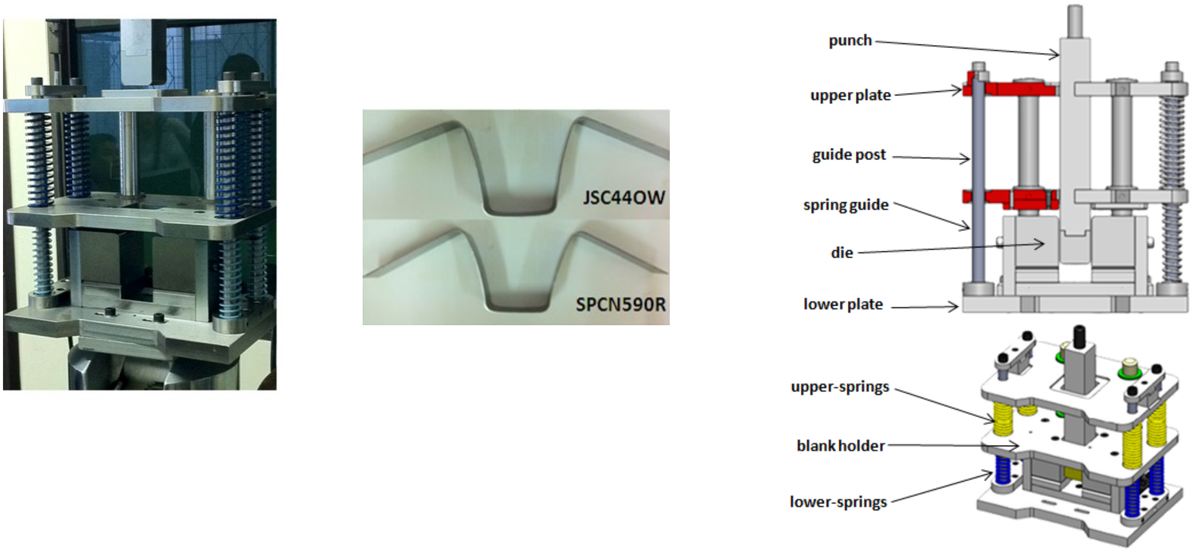

Figure 3 The components of U-bending dies, specimen and the installation in the tensile testing machine

In Fig. 4, the idea of using strain measurement device applied on the tools and dies design and tryout is illustrated.

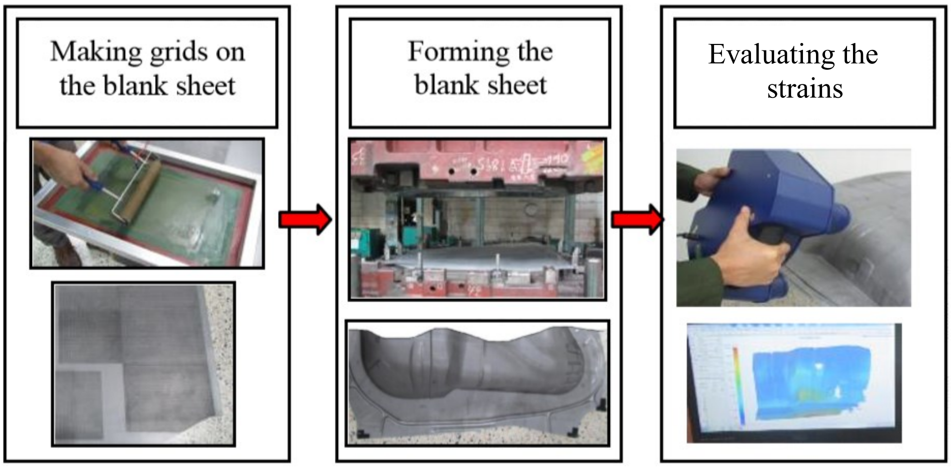

Figure 4 Shows the work flow by using the strain measurement device on the tools and dies design and tryout

Result and discussion

The result gathered from the first idea of using the strain measurement device for determining the FLD is presented. During the test, the specimen was captured along the deformation. The specimens with grid patterns were used to calculate the major strain and minor strain and displayed the result in a contour picture at the limit strain of tensile specimen. The AutoGrid® compact device provided information of deformation in a contour picture as displayed in Fig. 5. At the contour pictures number 1 and 2, the uniform elongation occurred at all of gauge length of specimens as shown in the uniform of color. At the maximum load, the contour picture number 3 illustrated the slight difference of color at the gauge length. The onset necking was occurred at the contour number 4 with significant difference of color between the center and the side of the specimen. This indicated that the forming limit curve was possible to generate by using the strain measurement device.

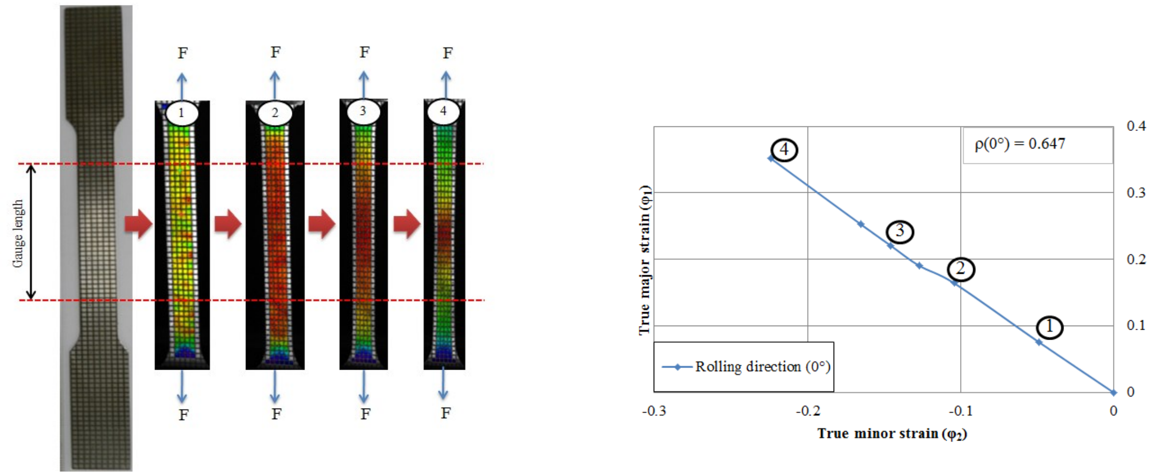

Figure 5 The major and minor strain distribution on the tensile test specimen obtained from the device

The result of the second idea was gained from using the strain measurement device for determining the strain distribution on the surface of U-bending specimen. To obtain the information in terms of the strain distribution, strain analyses were undertaken. The major strain (φ1) was directly measured on the outer surface. The distribution of major strain (φ1) of the outer surface is shown in Fig. 6. This information will assist the engineer in understanding the flowing of material and material behavior during U-bending test. Finally, the solution of the bending problem can be implemented.

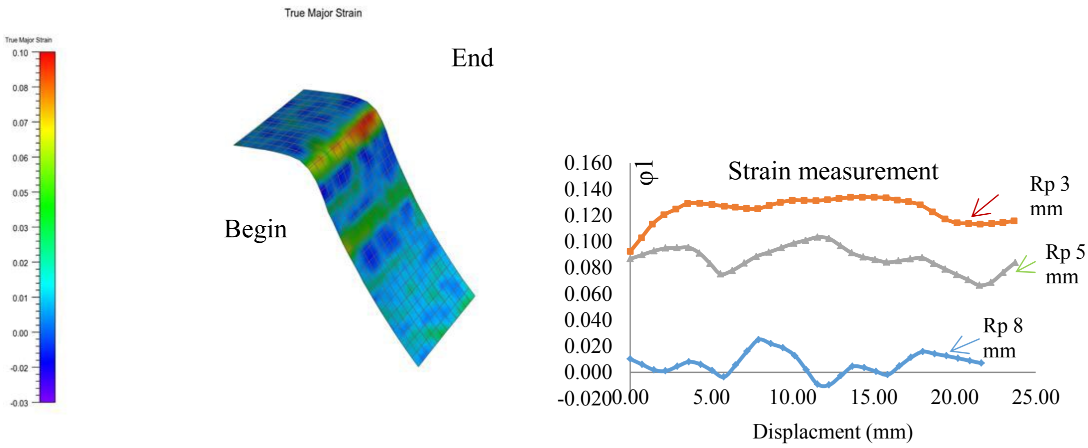

Figure 6 The strain distribution across the bending radius in different punch radius conditions

The third idea concerns the use of the strain measurement device in tools and dies design and tryout. The AutoGrid® Compact system can provide the strain information at critical area of stamping part. In Fig. 7, the stamping part obtained from the press shop has certain critical areas that need a special care in order to achieve the customer's requirement. Therefore, the strain measurement device was applied to measure the strain and thinning distribution on the part. This case is shown in the Area 1 and Area 2 of Fig. 7.

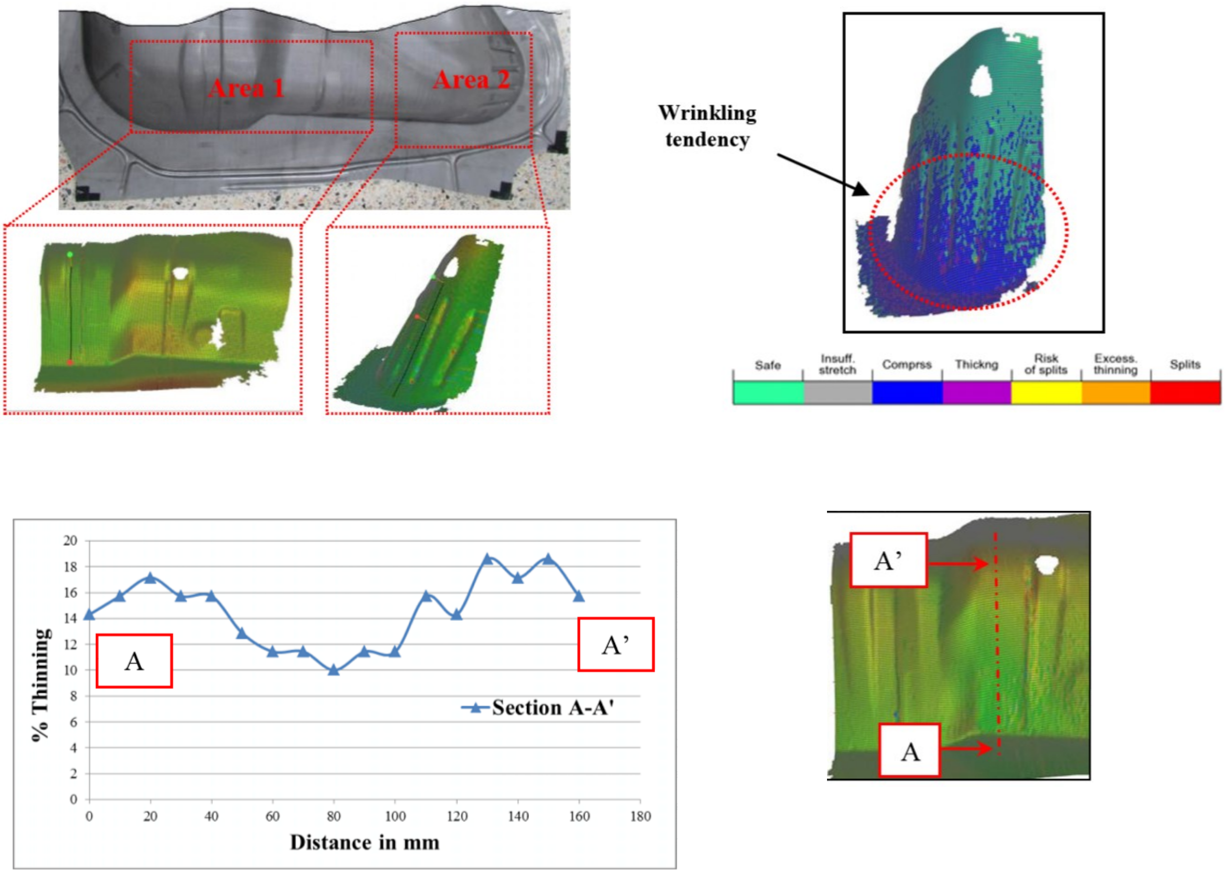

Figure 7 The thinning distribution and wrinkle tendency on stamping part

In Fig.7, the strain measurement device working with the specific design software for strain analysis is called AutoGrid® visualizer. The AutoGrid® visualizer calculated the strain and converted the strain in thickness direction into the thickness of stamping part. In addition, the sheet thickness of reduction or thinning distribution showed a specific area across the section. More importantly, the information about wrinkle tendency on stamping part was also provided.

Conclusion

In this paper, the modern engineering strain measurement system offers the possibility to determine the strain state during the phase of material testing, die design and tryout, as well as forming process. The engineer obtained the real strain information from this measurement device. Thus, finding the right solution for solving the problem can be implemented in a shorter time and with higher precision. Using the strain measurement device with skill on working and experience would provide the beneficial information for engineers to improve the product quality and reduce the lead time in production process and control.

References

[1] W.F. Hosford, R.M. Caddell, Metal forming mechanic and metallurgy 3rd edition, Cambridge, UK, 2007.

[2] W. Bleck, Material characterization 2nd edition, RWTH Aachen University, Germany, 2010.

[3] American Society for Testing and Materials, Standard Test Method for Determining Forming Limit Curves, U.S. 2008.

[4] K. Narasimhan, M.P. Miles and R.H. Wagoner, A better sheet-formability test, Materials Processing Technology, vol. 50, 1995, pp. 385-394.

KKU International Engineering
10.4028/www.scientific.net/AMR.931-932

Application of Using the Optical Strain Measuring Device in Material Testing and Tools and Dies Design

10.4028/www.scientific.net/AMR.931-932.317