APPLICATION OF DIGITAL IMAGE CORRELATION TECHNIQUE FOR MEASURING DYNAMIC PARAMETERS DURING IMPACT LOADING

S.Palanivelu[1], W. Van Paepegem[1], J. Degrieck[1], J. Van Ackeren[2], D. Kakogiannis[2], J. Wastiels[2], D. Van Hemelrijck[2], J. Vantomme[3]

[1]Ghent University, Department of Materials Science and Engineering, Sint-Pietersnieuwstraat 41, 9000 Gent, Belgium. Sivakumar.Palanivelu@UGent.be, Wim.VanPaepegem@UGent.be, Joris.Degrieck@UGent.be
[2]Vrije Universiteit Brussel, Department of Mechanics of Materials and Constructions, Pleinlaan 2 B-1050 Brussels, Belgium. Johan.Van.Ackeren@vub.ac.be, Dimitrios.Kakogiannis@vub.ac.be, jwastiel@irexchange.vub.ac.be, dvhemelr@vub.ac.be
[3]Royal Military Academy, Civil and Materials Engineering Department, Building G, Level 0, 8 Av. Hobbema B-1000, Brussels, Belgium. John.Vantomme@rma.ac.be

ABSTRACT: Traditionally, many contact sensors have been employed to collect the data during an impact test. Often to select the appropriate data acquisition equipments and sensors, prior knowledge of the magnitude of the peak crushing force and the duration of the crash event is important. However, this is not an easy task. Any improper selection would lead to loss of sensors and equipments. So a contact-less method is an interesting alternative to collect the data during such dynamic events. In this paper, the digital image correlation technique (DIC) is used to measure the impact velocity and the corresponding impact force. To validate the method an axial impact test has been carried out with different specimens such as polyurethane foam, empty metal cans and composite tubes. The effect of different parameters such as the frame rate and subset size on the impact parameters is evaluated.

1. INTRODUCTION

Often, collection of dynamic parameters during a dynamic test needs an extensive safety and selection procedures for the sensors. Accordingly dedicated sensors have to be used to measure the different dynamic parameters. Furthermore, the level of accuracy of these sensors can be affected by the selection and working environment variables such as sensitivity, mechanical interface, wiring harness, disturbing frequencies in the vicinity, coupling losses, operating temperature etc,. Hence, to eliminate the above mentioned constraints a contact-less method for measuring dynamic parameters is absolutely necessary. DIC can be adopted for such applications. DIC is an optical-numerical full-field displacement measuring technique. The technique is based on a comparison between images taken during loading of a specimen (Figure 1). For an optimal use of this method, the object of interest should be covered with speckle patterns. A few investigations have been made to use this technique for dynamic applications and the results of those experiments showed promising results. E.B. Li et al. [1] adopted this technique to measure the various rolling parameters such as neutral point location, neutral angle, forward and backward slips, the length of the contact arc and the coefficient of friction. Steve Vanlanduit et al. [2] proved that the DIC technique can be used to monitor the crack length from the displacement field during a fatigue test. This paper demonstrates to use digital image correlation technique to measure the dynamic parameters such as deformation-time history of the test specimens, impact velocity and the corresponding impact force during an axial impact event.

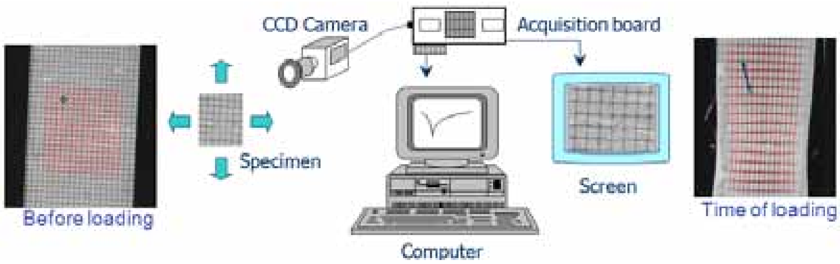
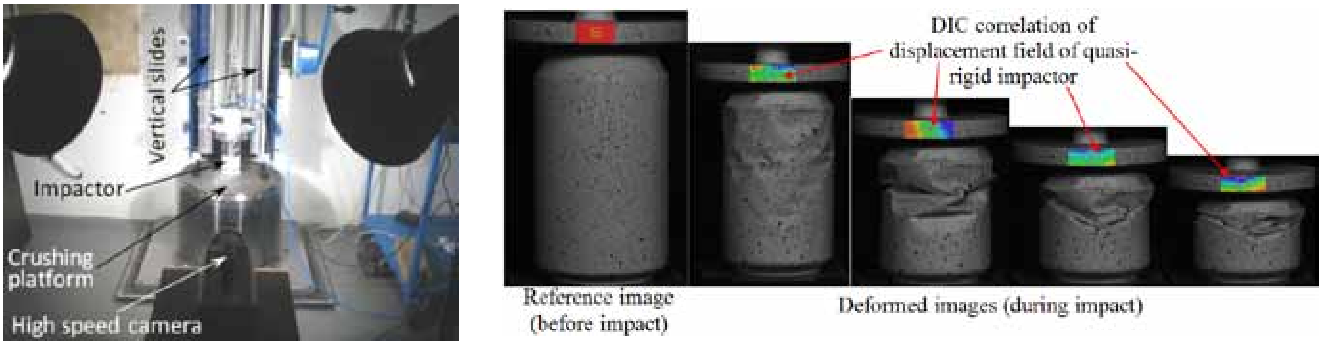


Figure 1: Working principle of DIC technique.

2. EXPERIMENTAL SET-UP AND METHOD OF CALCUALTION

The experimental set-up which was used for the small-scale impact tests is shown in Figure 2(a). In order to validate the DIC method for the calculation of impact parameters, axial impact tests were carried out with different test specimens (polyurethane foam, empty metal cans and composite tubes) for the impact velocity ranging from 1 m/s to 7 m/s. For each test a high speed camera was used to record the speckle pattern on the falling impactor. In addition to that, the acceleration, impact force and the displacement of the quasi-rigid impactor were measured using an accelerometer, force sensor and an inductive displacement sensor respectively. Performing correlation between the high speed images which are taken before and during loading finally yields the desired displacement-time history. The commercially available digital image correlation code Vic-2D was used to calculate the displacement-time history of the quasi-rigid impactor which is equivalent to the deformation-time history of the test specimen. Subsequently, the impact velocity and the deceleration were calculated by differentiating the displacement-time history. It was assumed that the deceleration of the quasi-rigid impactor was constant during one time interval. Based on this assumption the impact force was calculated by multiplying the mass of the quasi-rigid impactor with the deceleration data. Figure 2(b) shows the DIC correlation of one of the impact tests on metal beverage cans. Furthermore, the effect of different frame rate and subset size on the correlation of these parameters (displacement, velocity and the corresponding force) has been studied.



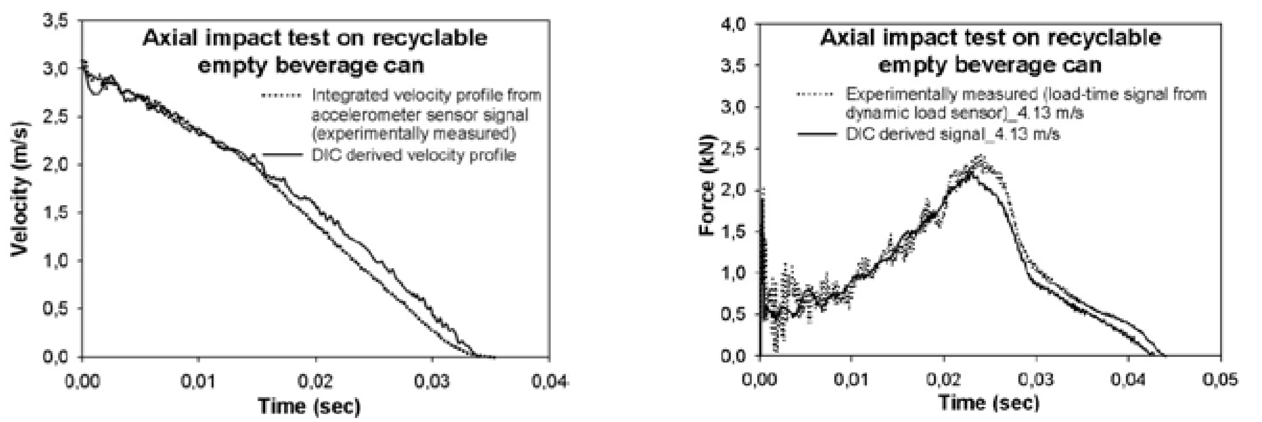
(a) Experimental set-up (b) Digital image correlation of crushing of metal beverage can

Figure 2: Details of experimental set-up and correlation of digital image correlation.

The values derived from DIC measurements were compared with the experimentally measured signals from load cell, accelerometer and the displacement sensor. The velocity of the impactor was calculated by integrating the acceleration signal from the accelerometer. The deformation length was compared with the inductive displacement sensor; furthermore, it was also validated with the integrated (twice) signal from the accelerometer. The reaction force signal was taken from the load sensor.

3. COMPARISON OF RESULTS

As an example, the results from the crushing of metal beverage cans are shown in Figure 3. Figure 3(a) shows the comparison of velocity-time history of the quasi-rigid impactor from experimental data (integrated signal from accelerometer) and with DIC processed data. Similarly, Figure 3(b) shows the comparison of force-time history of the quasi-rigid impactor from experimental (signal from force sensor) and DIC processed data for an initial impact velocity of 4.13 m/s.



(a) Comparison of velocity-time history of the impactor. (b) Comparison of force-time history of the impactor.

Figure 3: Comparison of velocity-time history and force-time history of the quasi-rigid impactor.

Finally this study demonstrates that the digital image correlation technique can be adopted for impact application to calculate the test parameters such as impact velocity and the corresponding reaction force in a contactless manner.

4. REFERENCES

[1]. Li, E. B., Tieu A. K. and Yuen W. Y. D., *Application of digital image correlation technique to dynamic measurement of the velocity field in the deformation zone in cold rolling.* Optics and Lasers in Engineering, 2003. **39**(4): p. 479-488.

[2]. Vanlanduit, S., Vanherzeele J., Longo R. and Guillaume P., *A digital image correlation method for fatigue test experiments.* Optics and Lasers in Engineering. **47**(3-4): p. 371-378.