APPLICATION OF DIGITAL IMAGE CORRELATION FOR CURVED SURFACES TO DETERMINE DEFORMATION

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ABSTRACT

Digital Image Correlation (DIC) is a powerful technique which is used to correlate two image segments to determine the similarity between them. A correlation image is formed which gives a peak known as correlation peak. If the two image segments are identical the peak is known as auto-correlation peak otherwise it is known as cross correlation peak. The location of the peak in a correlation image gives the relative displacement between the two image segments. Use of DIC for in-plane displacement and deformation measurements is well known.

The basic principal of Digital Image Correlation (DIC) for measuring surface displacement considering curve surface such as cam is described in this paper. These components on the surface of an object are easily obtained using this method by recording images of surface before and after deformation. It is a non-contact optical measurement system, capable of high resolution surface deformation measurements derived from digital images captured of a surface undergoing a deformation or wear. The methodology presented in this paper uses a high speed camera to capture images of the curve surfaces and curved shape parts such as cam, from which surface deformation and/or wear measurements can be made. Wild use of this method in various fields is expected because the measurement can be performed easily and simply. In many cases residually stresses surface layers that are obtained by surface treatment or coating deposition contains significant stress gradients. These gradients affect the performance of component surfaces under the conditions of contact loading in service, such as impact, scratch and abrasion, wear, erosion, fretting fatigue, etc. The determination of residual stress in the close vicinity of sample surfaces, at the depths ranging from sub-micron to a few microns, is a challenging task that cannot be accomplished routinely using existing techniques, such tasks are easily completed using DIC. Cracks induced by external excitation on a material that has defects may generate the stress concentration phenomenon.

Keywords:- *DIC, peak, correlation, Curve Surface, Cam, Deformation, Wear, High Speed Camera, stress.*

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1. INTRODUCTION

1.1 Digital Image Correlation

Digital image correlation (DIC) is a non-contact optical method where digital images of an object are captured and analyzed to extract full field shape, deformation measurements. The method compares images of the object in a non-deformed and deformed state in order to obtain relative measurements. Measurements are made by creating and then tracking a number of surface points in a sequence of digital images, typically of a surface undergoing some form of deformation. Surface points are reconstructed from the digital image data either in two dimensions (2D) using images from a single sensor, or in three dimensions (3D) using a synchronized images from a stereo camera system. A data point is created from a neighborhood of pixels (subset) within the digital image at the reference stage; this subset and associated data point is then tracked at sub pixel accuracy using correlation methods to match the same area of pixels based on the intensity values, in subsequent stages of deformation. A displacement field for a surface, from which deformation vector fields can be derived, is obtained by measuring the 3D displacement of data points at a discrete number of locations across the surface of interest. The resolution of a measurement is dependent upon the number and separation of data points created, this can be controlled by defining the distance, in pixels, that a subset is translated within the image before another data point is created, usually referred to as the step parameter [1].

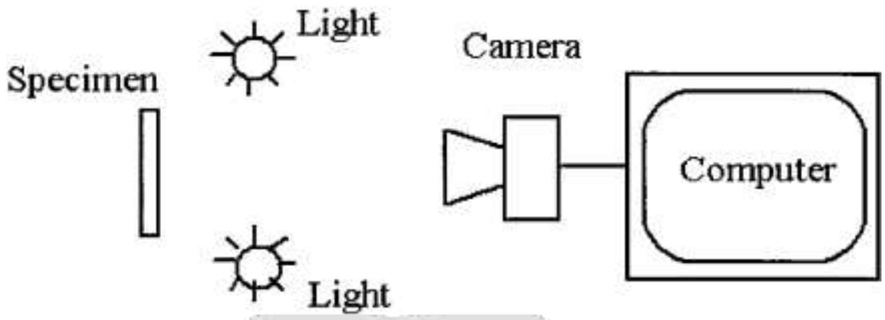


Fig-1 Schematic diagram of equipment for DIC

1.2 DIC Implementation

In the past, there are two methods for surveying strains developed in an object which in subject to external forces. One method is to measure the relative displacement between two specific points on the surface of an object, and then estimate the strain between these two points. However, the global strain distribution of the object cannot be determined directly. The other method is to map meshes on the surface of an object before deformation occurs, and then survey the displacement of nodes surrounding these meshes after deformation. Further, the strain distribution of an object is derived from the displacement field. Contrarily, this technique is a complex The Developed Digital Image Correlation (DIC) technique is an image identification method for measuring object deformation. The digital images of an object before and after deformation that are captured using an optic instrument are subject to correlation analysis. The corresponding positions recorded on the image are obtained by calculating the correlation coefficient of images so that the displacement function and strain distribution of an object can be inferred. This technique is non-destructive for inspecting the whole displacement and strain field. Recently, utilized an electron microscope to capture specimen images in a tiny region and then executed DIC analysis for these images. These results indicated that the precision of DIC method is in the Nano scale range. For the application of DIC analysis in crack problem acquired images of Nano scale objects using an atomic- force microscope to detect Nano-scale cracks forming on nano materials [2].

2. EXPERIMENTAL PROCEDURE

2.1 Methodology

Digital image correlation (DIC) techniques have been increasing in popularity, especially in micro- and nano scale mechanical testing applications due to its relative ease of implementation and use. Advances in computer technology and digital cameras have been the enabling technologies for this method and while white-light optics has been the predominant approach, DIC can be and has been extended to almost any imaging technology.

Digital image correlation and tracking is an optical method that employs tracking and image registration techniques for accurate 2D and 3D measurements of changes in images. This is often used to measure deformation, displacement, strain, and optical flow, but it is widely applied in many areas of science and engineering. Here we are going to take use of DIC technique to find out deformation of the cam using a good quality camera the image of cam before and after loading have to capture in camera available. The experiment is going to carry on the cam set up available in lab by providing the known amount of load in order to find the deformation of cam. The new cam is required for this as after some time of its working hours we are going to measure the wear of cam and speckled pattern should be spray on the surface of cam, of which we are going to take images. The speed of rotation of cam per minute is to be maintained such as there is jumping of follower so that cam is subjected to strain and may deformed. Once the setup is ready number of images is to be captured and is used in the MATLAB for the purpose of processing by coding in the software and the result will be obtained. Same results should be verified using the available method for the same. After getting the result of cam deformation for aluminium cam same test is carried out for MS material cam and results will be studied.

Experimental setup of DIC consist of

- Specimen.
- Camera.
- Digital correlation software

Chart 1 Flow of Methodology

2.2 Digital Image Correlation in MATLAB

The Digital image correlation software which we are going to use is MATLAB. MATLAB software has image processing tool. MATLAB performs the image processing, correlation and finally we get the required output i.e. strain. Matlab is a high-level technical language and interactive environment maintained by the Math Works Inc. It has a plethora of subroutines and built in functions dedicated to perform complex image processing and manipulations and when combined with user developed subroutines its capability becomes limitless. Images are stored as two-dimensional arrays, in which each element of the matrix corresponds to a single pixel in the displayed image that represents the intensity of the image at that point. Images can be added (imadd) or divided (imdivide), or image subtracted (imsubtract) to detect differences between two or more images of the same scene or to enhance or suppress certain features. In Matlab, images can also be stored as an array of complex exponential to manipulate frequency domain attributes. Frequency domain transform is useful for a wide range of applications, including convolution, enhancement, feature detection, and image compression.

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. MATLAB is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++ and Fortran A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, Fortran and Python. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems. In 2004, MATLAB had around one million users across industry and academia. MATLAB users come from various backgrounds of engineering, science, and economics. MATLAB is widely used in academic and research institutions as well as industrial enterprises.

The flowchart of image processing done by MATLAB is given below.

- START
- READ INPUT IMAGE
- CONVERT RGB INTO GRAY
- CONVERT GRAY INTO BINARY
- CROP IMAGE FOR TARGET AREA
- INVERT THE IMAGE TO MEASURE SPECKLE AREA
- CALCULATE CORRELATION FACTORS
- CALCULATE ENTROPY, VARIANCE, STD DEVIATION
- CALCULATE ELONGATION
- CALCULATE % STRAIN
- END

3. RESULTS

3.1 Image Processing

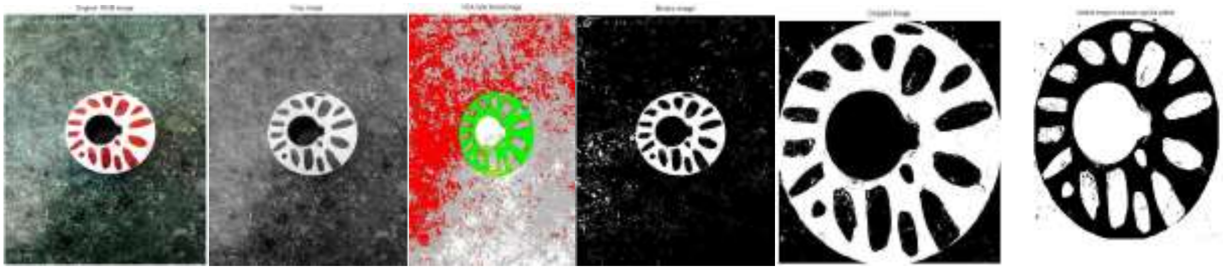


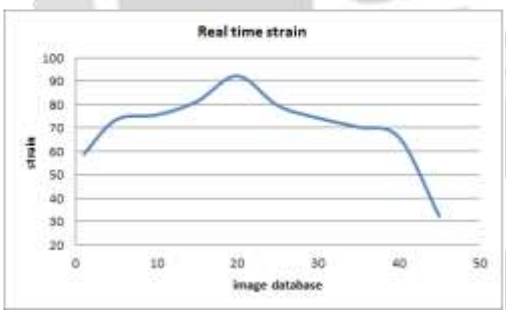
Fig-2 Processed Images in MATLAB

Image Condition	Entropy	Standard Deviation	Variance	Area	% Strain
Before Loading	0.9979	0.4992	0.2346	3.4128	64.0765
After Loading	0.9980	0.4992	0.2351	3.4456	65.6545

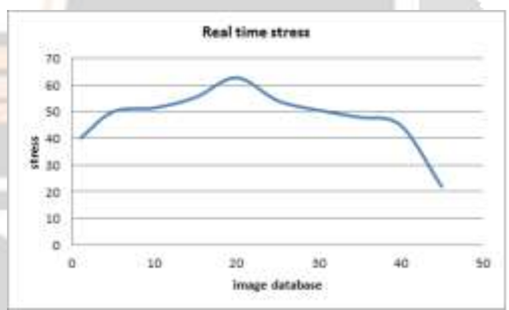
Table-1 of correlation factor measured by MATLAB for Al

Material	% Change in area	% Change in strain
Aluminum	0.9611	2.4627

Table-2 Results for Al



Graph-1 Real Time Strain from DIC



Graph-1 Real Time Strain from DIC

3.2 Validation for DIC

After completing the required experimentation and obtaining the output from Digital Image Correlation Technique it is important to check the accuracy of method in order to check the feasibility of results obtained above. Hence for the purpose of checking accuracy of DIC technique and validation of result another experiment is done on UTM machine. Using the aluminum bar and taking tensile test on it so that it is easy to valid results comparing the results obtained from UTM and that of DIC method. The sample bar was prepared as per the requirement for testing on UTM machine and application of speckle pattern is done over it for image processing purpose. Preparation of sample for testing is shown below. The circular aluminum bar with 12 mm diameter and speckle pattern is loaded on UTM machine and the images are captured until the test sample breaks.

Fig-3 Validation of Al Sample over UTM Machine

3.3 Validation Result

Particular	UTM Results	DIC Results
% Elongation	27.42	25.00
Accuracy of DIC Method = 91.17%		

Table-3 % Elongation validation

4. CONCLUSIONS

- This paper has presented a methodology for deformation measurement of curve surface i.e. cam.
- Results are more accurate within elastic limit hence results for cam are correct as reading was took within elastic limits.
- The correlation analysis is done irrespective of the material and the shape of the object.
- The experiment conducted shows that DIC is non-contacting method for deformation analysis.
- The specimen was applied with random speckle pattern, by using paint. The image analysis alogrithm makes it possible to automatically correlates the deform and undeform image with the help of random speckle pattern and matlab software.
- Accuracy is depends upon the quality and stability of camera during experimentation.

6. REFERENCES

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