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# Digital Image Correlation Technique for Strain Measurement of Aluminium Plate

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***Abstract*** *— The Digital image correlation technique recently developed is an image identification technique to be applied for measuring the object deformation. This technique is capable of correlating the digital images of an object before and after deformation and further determining the displacement and strain field of an object based on the corresponding position on the image. Digital Image Correlation (DIC) is an upcoming experimental stress –strain analysis technique and has certain advantages over others. DIC can be tested on almost all material with a large area of inspection and no pre treatment is required as compared to other optical methods. DIC uses the principle of image correlation and produces strain field by analyzing the movement of marked points on the subject. The Digital Image Correlation (DIC) is a state of art technique that can be used for accurate strain measurement. Because of its capability for fast data acquisition, this technique is well suited for the characterization of material properties both in the elastic and plastic ranges. It also has advantages of full field, non- contact, and considerately high accuracy for displacement and strain measurements. The MATLAB software is an innovate system that uses the digital image correlation technique to provide strain measurements in a two-dimensional contour map for planar surface specimens*

**Keywords —** *DIC, Strain, Deformation.*

## I. INTRODUCTION

The engineering design of structures requires a knowledge of the basic principles of stress and strain.. A strain in any material can be defined as ratio of change in length to the initial length. Strains are involved in many important material properties and parameters Recently, new and more cirtical investigations are requiring strain measurements at any point inside an area of interest to improve the study of the behaviour of materials and structural components. Some traditional instruments, which measure strains, are not able to create strain maps, because it would be very costly and not practical. Due to these limitation, a new technology was develop to obtain these desired results. This new technology is the digital image correlation, which provides a contour map of strains of an

entire specimen surface subject to mechanical tests. DIC is widely applied in many areas of science and engineering. Due to rapid developments in high resolution digital cameras for static and dynamic applications, and computer technology, the applications for this measurement method has broadened and DIC techniques have proven to be a flexible and useful tool for deformation analysis. Digital Image Correlation is an innovative non-contact optical technique for measuring strain and displacement. DIC is simple to use and cost effective compared to other techniques.

## II. LITERATURE REVIEW

The concept of using correlation to measure datasets has been known for a long time, and it was applied to digital images at in 1975.Much early work in DIC in the field of mechanics was led by researchers of University of South Carolina in the early 1980s and has been optimized and improved in recent years Peters & Ranson studied the digital image correlation (DIC) method is widely used in experimental mechanics as a practical and effective tool for full-field deformation measurement[1]. Further Zhou & Chen studied that DIC technique is easy to manipulate and can provide satisfactory resolution of displacement and strain fields [2]. Koerber & Xavier studied that DIC technique is used for quasi-static and high strain rate experiments in order to obtain the in-plane strain field over the entire specimen surface .[3] Pierron & Sutton in their experiment used a high speed camera for the high strain rate experiment, in which specimen deformation was monitored and fields method of a 3 point bending was analyzed.[4] Li Gong & Zhon studied the behavior of rock, by increasing the depth of underground excavation and observed that it is difficult to explain by traditional theories. [5].Vellinga & Onraet studied the Cracks developed by external excitation on a material that has defects may create the stress concentration phenomenon.In this work, the technique is applied to analyse the mechanics of a cylindrical pipe experiencing crack destruction. The device is fixed to avoid shaking the specimen during the pressurizing process. The image capture instruments i.e camera is fixed on the stable frame to measure the deformation of specimen accurately. Through the cylindrical pipe cracking

test, the capacity of the digital image correlation technique for surveying the strain variation in a tiny region is validated. Then, the experimental results obtained using the digital image correlation analysis is used to demonstrate the crack development tendency in defect materials and the stress concentration zone.[6] This research work demonstrates that the DIC method is an appropriate technique for image identification with high precision. This technique is applied to analyse the mechanics of a fixed cylindrical pipe experiencing crack destruction. In order to have accuracy of DIC method, the specimen and camera must be fixed on stable device to avoid shaking effect. According to analysis results presented in this paper, the strain distribution of DIC analysis is similar to that of numerical simulation under the exertion of lower internal pressure. J.G. Zhu & H.M. Xie & Y.J. Li & Z.X. Hu & Q. Luo & C.Z. Gu studied the residual stress in thermal barrier coatings (TBCs) fabricated from coating deposition plays a vital role in the coating design and processing parameters optimization. The main objective of the present work is to determine the interfacial residual stress in TBCs by means of miniature ringcore cutting and the digital image correlation (DIC) method. Both the ring-core cutting and the dot pattern used for DIC deformation measurement are implemented by the focused ion beam (FIB) milling on the cross-section of a coating. A finite element model (FEM) is developed to simulate the ring-core cutting process. From the FEM, the calibration coefficients are determined for general applications. The surface of the ringcore containing dot patterns is recorded before and after the FIB milling process. DIC technique is then performed to calculate the surface displacement caused by the release of residual stresses due to the cutting. Results shows that the interfacial residual stress in TBCs is nearly in a uniaxial stress state and has a tendency to be compressive toward the interface The study provides a detailed description of interfacial residual stress analysis of thermal spray coatings by a combined miniature ring-core cutting and DIC method.[7]

## III. PROBLEM DEFINITION

Measuring strain is very essential in engineering. Due to certain limitation of traditional method DIC technique is used for measurement of strain. Geometry of the specimen may alter during testing of the specimen ,if the specimen is very small, striped –shaped or very complicated and influence the measurement, if we used traditional method. An image correlation deals with complicated shape and with any shape geometry. To obtain strain by traditional method, typically an extensometer is attached to specimen to determine the strain. This is not ideal, for all cases as it increases the strength of sample, and can damage the specimen itself and induce additional error in measurement .this problem is overcome by DIC technique by removing the measurement device from the environment of the test and from contact with To overcome the limitations of traditional method, DIC technique is used in analyzing strain induced in aluminium plate.

## IV. OBJECTIVE

Aim of this project is to measure the mechanical property i.e. strain of aluminium plate which is subjected to loading, by using non contacting method i.e. Digital image Correlation method

## V. METHODOLOGY

The method which we are going to use to achieve our objective is digital image correlation method. In these method the specimen is subjected to loading and images of the specimen are taking at an interval of 3 sec. the images are taken till the specimen breaks. These images are taken by high speed camera. The images captures by camera are given to DIC software for further correlation.

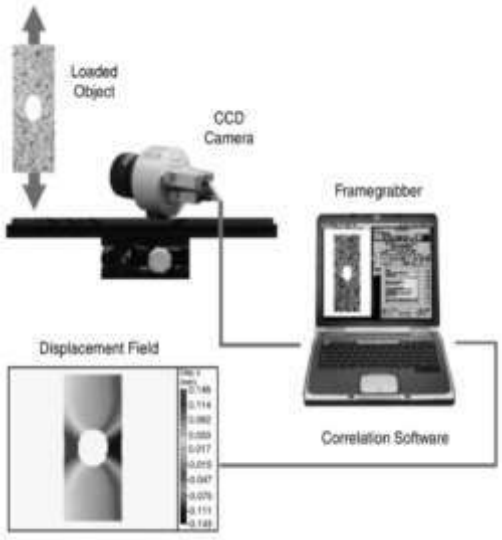


Fig1: DIC setup

Experimental setup of DIC consist of
A. Specimen
B. Camera
C. Digital correlation software

*A. Specimen*

By using Digital image correlation we can find out mechanical properties of various machine components. The specimen we use is aluminium

plate. . In this study we are going to use rectangular plate of aluminum whose dimension are 30 ×6×2.54 cm. In this project we are going to measure the strain on the aluminium plate which has number of application such as in processing industry, consumers good, marine environment, indoor parts of car frame and other pressing. The specimen whose strain is to be measured should have the random dot pattern. The random dot pattern are called as speckle pattern. The speckle pattern are necessary because it allows the software to identify and calculate the deformation with accuracy. To have more accurate result, the specimen should be sprayed with speckle pattern. The speckle patterns must in black colour and of various shape and size. Speckles can be produced on surface specimen by using spray, brush or stamping

Fig 2: Aluminium specimen Fig 3: Speckle pattern

*B. Digital Camera.*

The camera which we used for taking images is of sony xeperia T2 ultra. It is a high speed camera which has resolution of 16: 9 aspect ratio.

*C.Digital Image Correlation Software i.e 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.It has various number of inbuilt functions which are useful for image processing. Matlab can perform complex image processing .Images can be added, substracted or divided to detect the difference between two or more images

We are going to find strain by two method

A. By taking tensile test on UTM

B. By using DIC technique

*A. Tensile test by UTM machine*

The specimen is fixed in UTM machine. The load is applied in KN starting from zero. The is load is applied in increasing manner till the specimen breaks and finally the graphs are plotted.

Fig4: UTM Machine

*B .By DIC method.*

In DIC method the specimen is subjected to tensile test on UTM. The load is applied on the specimen until it breaks. The images are taken by the camera when no load is acting on the specimen, till the maximum load acting on the specimen. So in these way the images of the specimens which is undergoing deformation on application of the load are capture by the camera at an interval of 3 sec. The images of the specimens are taken until the specimen breaks. The time required to break aluminium plate on application of load (kN) is approximately 14 min. In 14 minutes we got 280 images at an interval of 3 sec. These images were exported to matlab software for further correlation to achieve the objective.

Fig5: Undeform Image

Fig6: Deform image

The processing of the images done by the MATLAB software is given below

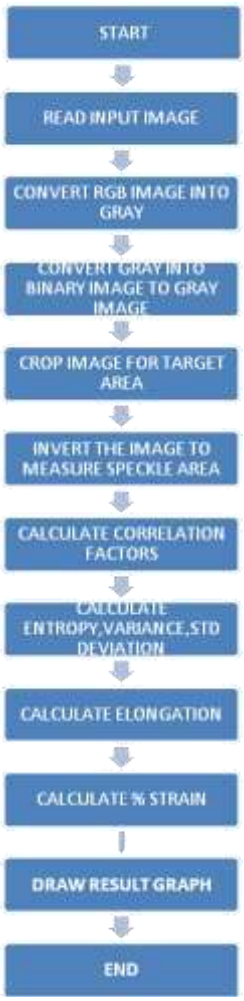


Fig7: Flow Chart of DIC

## VI. RESULT

The results are obtain in the form of graphs by both tensile test done on UTM and by DIC method i.e by MATLAB

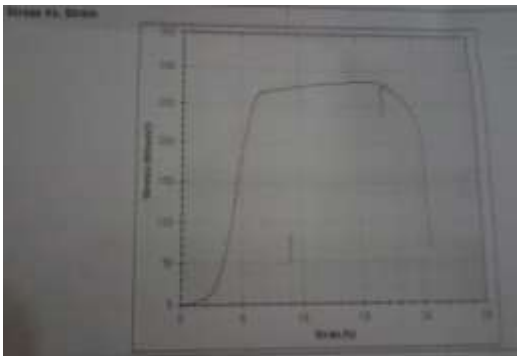

Fig8: Graph of strain versus stress obtain from UTM

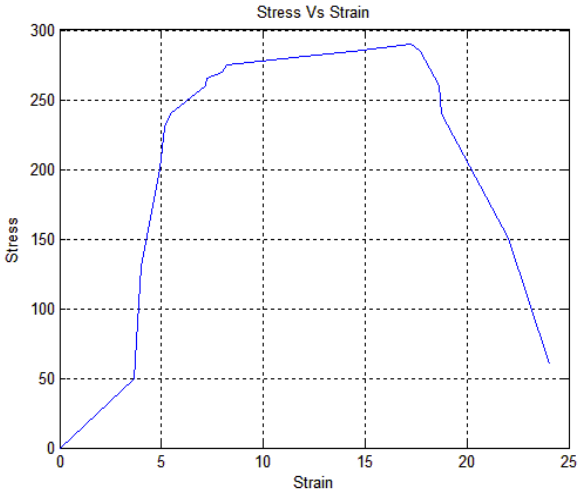


Fig 9: Graph of strain versus stress obtain from DIC software

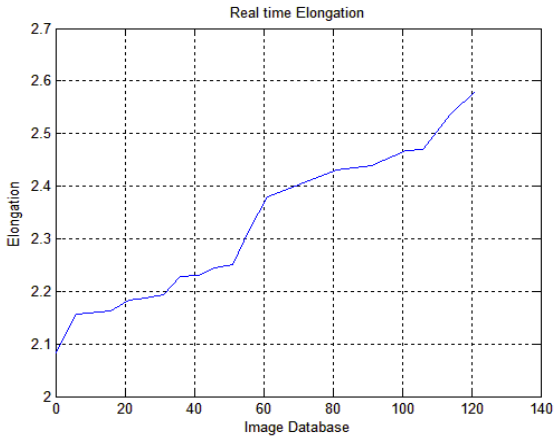


Fig 10: Graph of Elongation versus image database obtain from DIC software

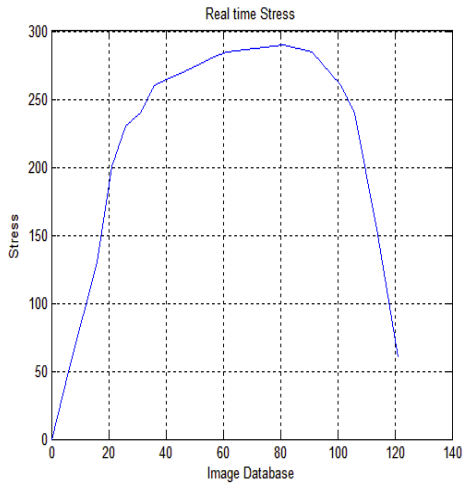


Fig11: Graph of stress versus image database obtain from DIC software

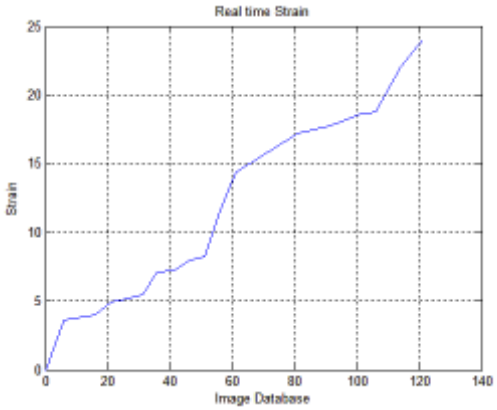


Fig 12: Graph of strain versus image database obtain from DIC software

## VII. CONCLUSION

The strain measured by UTM is 22%.The strain measured by DIC is 24%.Nature of graph obtain by DIC and UTM is same. The experiment conducted shows that DIC is non-contacting method for deformation analysis.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.

## VIII. FUTURE SCOPE

Digital Image Correlation (DIC) is a 3D, full-field, non-contact optical technique to measure deformation, vibration and strain on almost any material. The technique can be used for many tests including tensile, torsion, bending and combined loading for both static and dynamics applications. The method can be applied from very small (micro) to large testing areas. In DIC techniques multicamera can be use for accurate result Techniques can be used to measure strain and various mechanical properties of critical machine component in working condition within any contact with the machine component.

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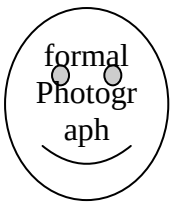


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