2024년 춘계학술발표대회 : 일반부문

디지털 이미지 상관을 위한 워터 디칼을 사용한 혁신적인 스펙클 패턴 응용

Innovative Speckle Pattern Application Using Water Decal for Digital Image Correlation

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Abstract

This study introduces a novel method for applying speckle patterns in digital image correlation (DIC) analysis, utilizing film-free water decal technology from SunnyScopa. Traditional speckle pattern application methods, such as spray painting, have inherent limitations, prompting the exploration of alternative approaches. In this experiment, two speckle pattern application methods were tested: traditional spray painting and the proposed method using film-free water decal. Each method was applied to three steel coupons, and strain gauges were affixed to the back of each specimen. Subsequently, the specimens underwent tensile testing to induce deformation. Both DIC results and strain gauge data were collected and compared between the two application methods. The analysis includes an assessment of relative accuracy, highlighting the effectiveness of the novel water decal approach in enhancing speckle pattern application for digital image correlation.

키워드 : 디지털 영상 상관관계, DIC, 스펙클 패턴, 워터 데칼
Keywords : digital image correlation, DIC, speckle pattern, water decal

1. Introduction

Digital Image Correlation (DIC) has become a widely used technique in materials science and engineering for non-contact, full-field measurement of surface deformations [1]. One critical aspect of DIC analysis is the application of speckle patterns on the surface of specimens, which serves as the basis for tracking deformation, as the speckle patterns are considered carriers of deformation information [2, 3]. Traditional methods of applying speckle patterns, such as spray painting, often present challenges in achieving uniformity and repeatability. Some studies have attempted to solve these problems by using thermomechanical processes to apply toner ink to a surface [5,6], but these methods still have limitations such as sensitivity to time and the requirement of sandblasting, rendering them inapplicable to painted surfaces.

This study proposes a novel method for applying speckle patterns in DIC analysis, utilizing commercially available water decal. Water decal, typically used for decorative purposes, offers advantages in terms of ease of application and adaptability to various surface types. Specifically, Film-Free Water Decal from SunnyScopa was chosen for its compatibility with DIC applications and its ability to provide high-resolution speckle patterns. This type of decal paper allows transfer of any design onto any surface, with no remaining film, unlike traditional decal paper. An image is printed using a standard laser printer, applied to a surface, and after the film is removed, only toner ink remains on the surface.

2. Methodology

2.1 Specimen Preparation

The experiment was designed to compare the performance of the proposed water decal method with that of traditional spray painting. Steel coupons made of SS275 steel were selected as specimens. Three specimens were speckled using spray painting, while the speckle pattern for the other three was produced using film-free water decal. The geometry of the coupons, based on ASTM E8/E8M-22, is shown in Figure 1.

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이 연구는 2016년도 정부(교육부)의 재원으로 한국연구재단의 지원을 받아 수행된 기초연구사업임. 과제번호:2016R1A6A1A03012812

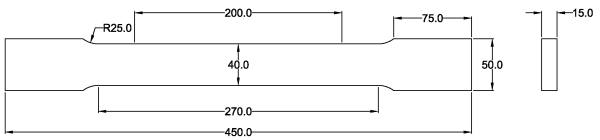


Figure 1. Geometry of SS275 coupons

For the spray-painting method, steel coupons were cleaned and sprayed with white paint. After drying, black paint was sprayed for the speckles. In contrast, for the water decal method, a digital speckle pattern with a 0.45mm point size was obtained from the GOM Aramis app, then printed on film-free water decal using a laser printer. The printed decal paper was then cut and carefully applied to the surface of each steel coupon using just water and special glue intended for the product.

2.2 Experimental Test

The specimens were then subjected to tensile testing using a universal testing machine with a crosshead speed of 4.05 mm/min in accordance with ASTM E8/E8M-22. Strain gauges were attached to the back of each specimen to provide additional strain data for validation purposes. DIC cameras captured images of surface deformations throughout the testing process. The camera used was the GOM Aramis 12M 2D System. The image capturing and processing software used were GOM Snap 2D 2019 and GOM Correlate 2019, respectively.

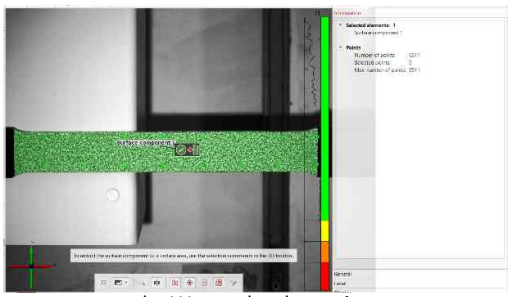
3. Results

The quality of speckle patterns on the specimens was assessed using the built-in feature of the software, as shown in Figure 2. Analysis of the DIC results reveals differences in the quality and uniformity of speckle patterns applied using the two methods. While traditional spray painting exhibits some inconsistencies and irregularities in speckle pattern distribution, the water decal method consistently produces high-resolution speckle patterns with minimal variation. These findings suggest that the proposed water decal method offers a viable alternative to traditional spray painting for speckle pattern application in DIC analysis.

4. Conclusion

Speckle patterns are crucial in DIC analysis, demanding a flexible method to overcome issues associated with spray painting. This study demonstrates the effectiveness of the proposed water decal method, providing a reliable and efficient alternative that offers consistent, high-resolution patterns. The results underscore the potential of water decal technology to enhance the accuracy and reliability of DIC analysis in materials testing applications. Further research and development could lead to widespread adoption of water decal-based methods in digital image correlation.

a. Spray-painted specimen



b. Water decal specimen

Figure 2. Speckle pattern quality assessment

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