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Fatigue in Polymers

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Abstract

This project involved the design and construction of a machine that would apply fatigue to a polymer sample. Fatigue is the result of a material being subjected to repeated loading and unloading or also stated as cyclic stress. By building a machine that can apply a cyclic stress to polymer sample, a fatigue limit can be found. Knowing this fatigue limit, a better understanding of the strength of the material can be gained. At low frequency, polymer fatigue failure becomes less related to test frequency but more related to the initial cracks and their resulting propagation through the sample. The resulting internal stresses and crack can then be seen and studied using a polariscope and underwater acoustic apparatus. With this machine, a better understanding can be gained about different types of polymers and their respective strengths.

Introduction

Little research has been performed in the study of fatigue in polymers. Because of this, not a lot is known about fatigue life or the affects of initial surface or internal stresses. The first step to learn more about polymers led to the design and construction of a fatigue machine as seen in Figure 3. The second step was to examine the samples using two methods. This examination would be performed once before being fatigued and again after being fatigued. This data could then be compared to see if it lead to a better understanding of how initial stresses were affecting how a material fatigued.

Methods

- *Polariscope* - an optical inspection device used to detect internal stresses in materials such as polymers. A polariscope is composed primarily of a light source and two crossed polarized lenses.
- *Ultrasound* – a technique that can be used for studying materials to find imperfections on the surface and within the material. This device is primarily composed of a transducers connected to an oscilloscope.
- *Cyclic Fatigue* – a force applied and then removed and performed repeatedly, on a sample. At low frequencies, this method of testing materials can expose initial stresses on and in the sample. The device is primarily composed of a forcing arm imposing a four point load onto a sample.

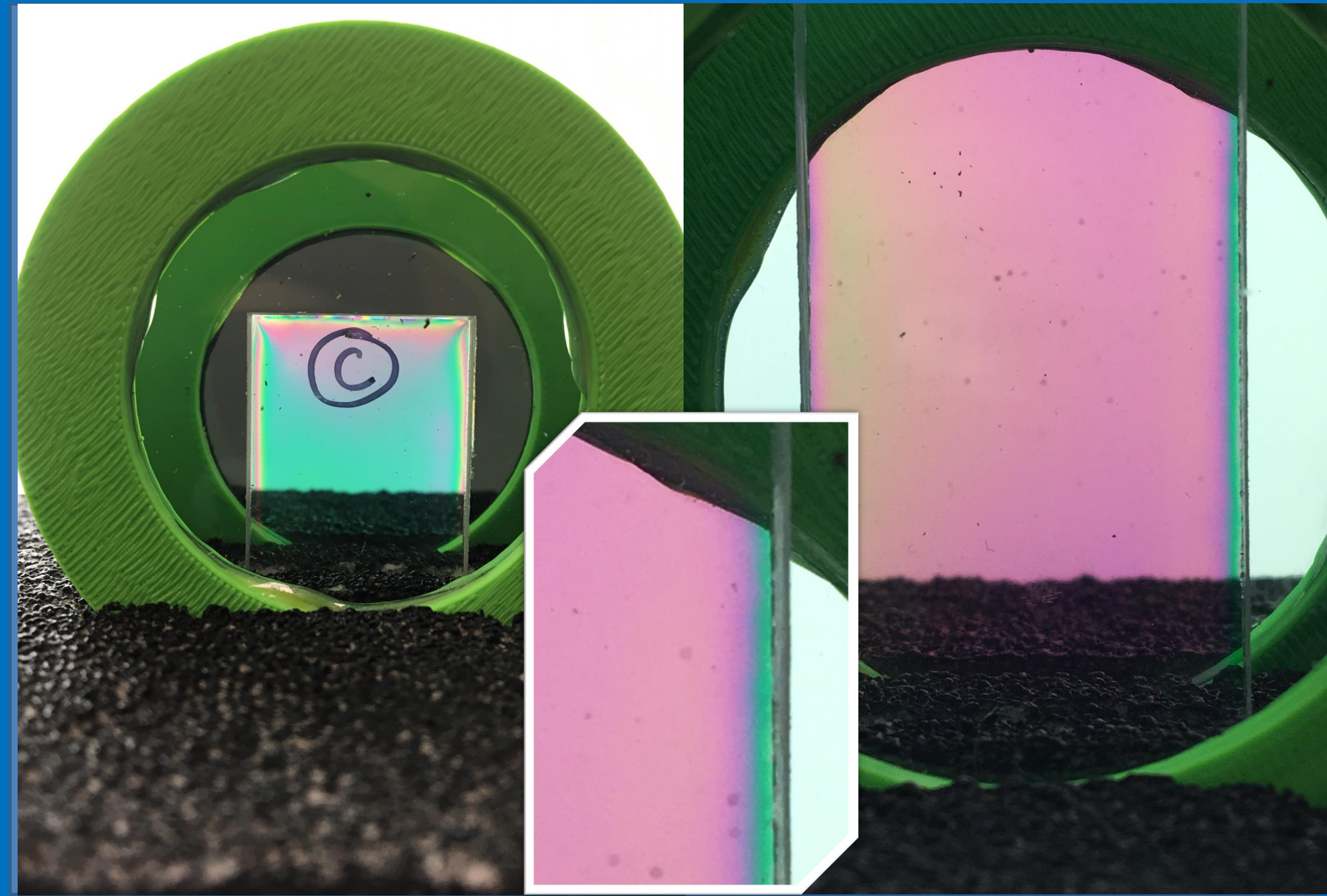


Figure 1. Polariscope – optical inspection device



Figure 2. Ultrasound – sound waves emitted from a transducer

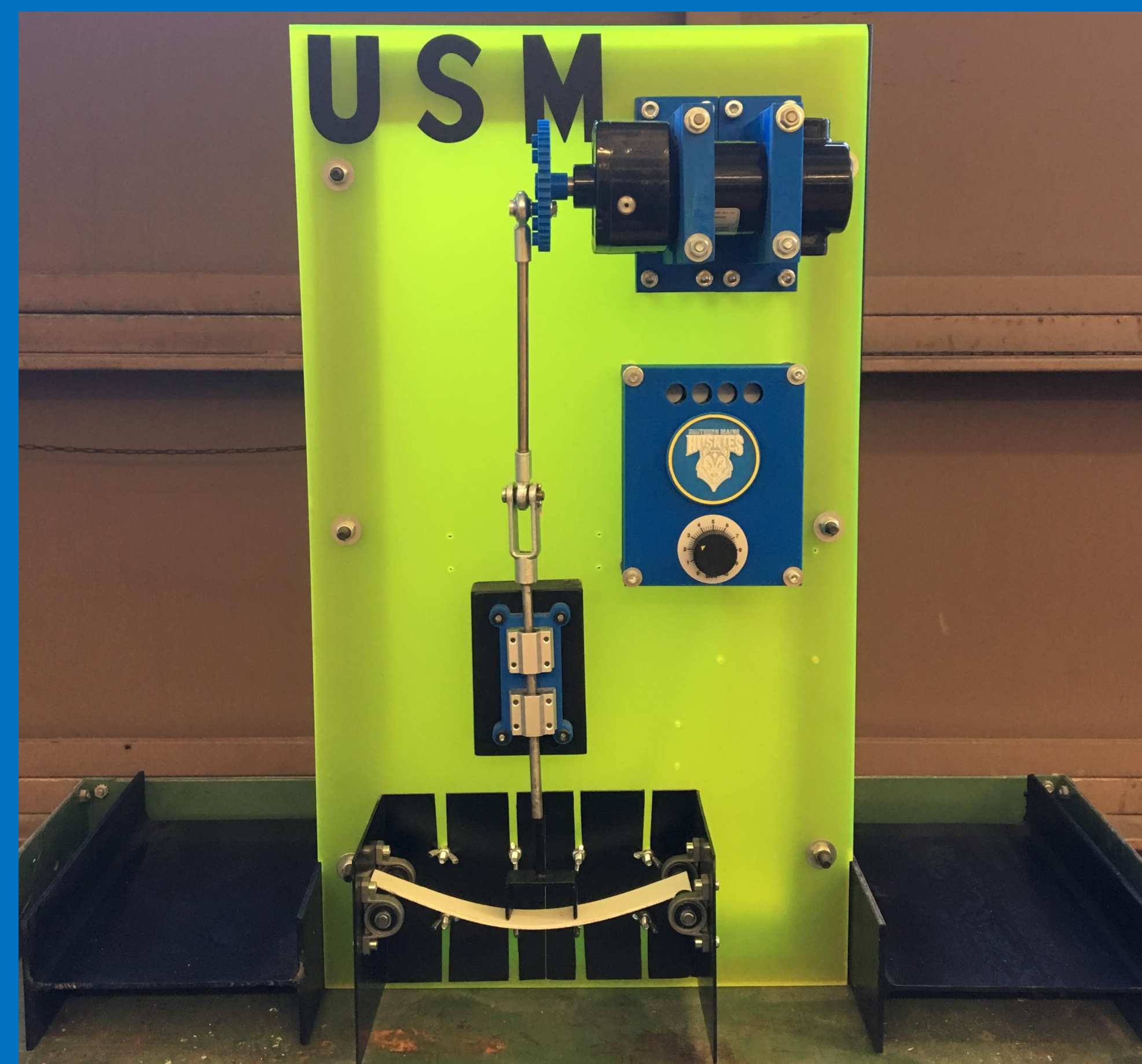


Figure 3. Fatigue Testing – loading and unloading

Objective

- Use a Polariscope to see initial internal stresses (see Figure 1.)
 - Use Ultrasound to collect initial internal data (time and Amplitude)
 - Use Ultrasound to collect initial external data (time and Amplitude)
- Fatigue samples a set amount of times (see Figure 3.)
 - Use a Polariscope to see if any new internal stresses have developed
 - Use Ultrasound to see if internal data has changed (time and Amplitude)
 - Use Ultrasound to see if external data has changed (time and Amplitude)
- Repeat steps 1-4 an additional set amount of times

Results & Discussion

In this study, three samples were tested. These three samples were labelled A,B, and C and varied in thickness. An initial examination was performed using a Polariscope as seen in Figure 1. As can be seen by the color variation along the edges of sample C, there was some initial internal stresses probably as a result of cutting the samples.

The second method used to examine the internal and also the external stresses was by means of an ultrasound device. This device was first used with a transducer and receiver to study the internal properties. Secondly just the transducer was used by itself to study the surface of the samples.

After gathering initial data, fatigue could applied to the samples as can be seen in Figure 3. After performing a set number of cycles, the samples were reexamined using the above stated methods to see if any changes had occurred. This was repeated several times until a noticeable distinction in the material could be seen. (at the time that this study was submitted, no conclusions had been realized)

Acknowledgements

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