Team 2: Biaxial Stress-Strain Fixture

Deliverable 1: Needs Assessment Report

Sponsor

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Needs Assessment:

There is a need for a biaxial tensile test fixture that can test multiple types of materials and used with a uniaxial MTS machine.

Project Scope:

Problem Statement:

Compression data is difficult to gather for gasket material due to the other stress states that appear while testing. When a biaxial tensile load is applied the resulting state is compression. The purpose of this project is to build a biaxial tensile test fixture that can be used with existing MTS machines without any modifications. The final design will be used for the quantity control testing of gaskets during production.

Justification/Background:

Gasket material is a fiber-reinforced-composite. This is a multiphase material that is artificially made. The orientations of the fibers have significant influence on the compressive properties of the materials. The mechanical responses are greatly dependent on the stress-strain behavior of the fibers as well as the direction in which the load is applied. For this type of composite, the matrix will typically yield as the fibers continuously deform plastically. Because of the anisotropic behavior of the gasket material, a reproducible mechanical properties test needs to be developed.

Biaxial test data is difficult to acquire due to the rarity of the actual test fixture. In order to reduce the cost, a test fixture that can be mounted in existing uniaxial testing machines needs to be developed. There are none as of now that are commercially available. Therefore, the goal of this project is to design and build a test fixture that Cummins Inc. can directly implement in their test facility with their existing equipment.

Objectives:

The objective of this product is to design and produce a mechanical device capable of transforming a uniaxial tensile tester into a biaxial tension tester for gasket materials. This device must:

- Perform uniaxial motion that is directly proportional between the perpendicular axis of the MTS machine and the device.
- Be capable of being used in an MTS machine without making alterations to the machine.
- Be simple enough to be installed, removed and used by any technician.
- Be constructed from materials that are readily available and of a low enough cost so that the device will be commercially viable.
- Be tested rigorously to ensure that it is durable over hundreds if not thousands of cycles without the need for maintenance.

Methodology:

Background (September 2013)

1. Research existing designs and identify strengths/weaknesses of each.
2. Obtain specifications of MTS machine for retrofitting.
3. Find parameters of operation
    -Stress to be endured.
    -Size of device required to test specimens.
    -Method of specimen attachment.

Ideation and Invention (October 2013)

1. Develop several conceptual designs.
2. Build preliminary prototypes using inexpensive or free materials to obtain a better understanding of how devices will actually operate.
3. Refine prototypes to operate better in the real world.

Design Selection (November 2013)

1. Use a selection matrix to choose a prototype that will best fulfill the requirements of the product.

Preliminary Design (November and December 2013)

1. Make detailed drawings of device.

2. Select materials.

3. Construct a robust prototype.

Testing and Refinement (January and February 2014)

1. Run prototype through many cycles.

2. Identify deficiencies.

3. Refine design and return to first step until all performance specifications are exceeded by a safety factor to be determined in design process.

Final Product Design and Manufacture (March and April 2014)

1. Produce detailed final drawings suitable for manufacturing.

2. Select most efficient manufacturing process.

Constraints:

- $2000 Budget
- Cost of product plus cost of uniaxial MTS machine must be significantly lower than the cost of a biaxial MTS machine
- Prototype must be built so that samples can be tested for design's validity
- Final product must be able to last and not be subject to premature failure due to design
- Must be designed as to not require an alteration on MTS machine
- Must be a consistent way to test samples
    - There is a part of the sample that receives equal tension in both directions, for example

Expected Results:

By the end of this first semester, it is required to have a completed design and working a prototype almost in working order. The final semester will be spent testing the machine with a uniaxial MTS machine on several samples provided by Cummins. The design will be able to test samples with many different elastic moduli keeping a consistency of results.