High Temperature Tensile Testing

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Introduction

The goal of this research project is to design a functioning high temperature tensile tester. Materials act differently at high temperatures. A preexisting tensile tester will be retrofitted to allow for high temperature testing. Digital image correlation (DIC) will be utilized to allow for a non-contact data acquisition method to record strain in the test sample.

This project is in the design phase.

- The sample grips needed to be designed to withstand max temperature of ~1400˚C
- The DIC camera set up needed to be researched, designed and purchased
- All these requirements need to be compatible for a furnace with a small viewing window

Test Apparatus

- Tester will be mounted on to the test frame
- Furnace will be placed inside of the tensile tester
- Grips will be inside the furnace area
- DIC camera system will use viewport in furnace

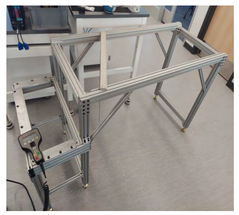

Fig. 1 Test Frame.

Fig. 2 Amteco HFRS-350-3Z Furnace [1].

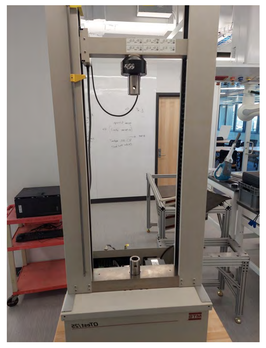

Fig. 3 Tensile Tester.

Digital Image Correlation

High temperature digital image correlation has inherent difficulties

- Metals glow at higher temperatures
- The hot air surrounding sample will cause distortion in the images, also known as heat haze
- Speckle patterns are inconvenient due to increased complexity of sample preparation

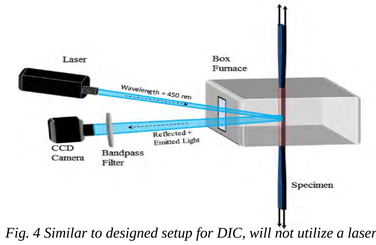

Fig. 4 Similar to designed setup for DIC, will not utilize a laser [2].

The design limitations of DIC can be overcome with different design considerations

- Higher frequency wavelengths do not show as much glow distortion so a LED blue light with a blue filter will be utilized
- Instead of using speckle patterns on the sample the DIC software can use different imperfections on the sample as reference points

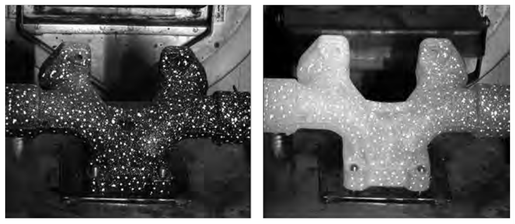

Fig. 5 High Temperature DIC, left is filtered with blue light, right is unfiltered light [3].

- Current camera system design will be a FLIR Oryx camera with a c-mount 45mm macro lens and a blue light filter and a square blue light LED

Fig. 6 FLIR Oryx camera [4] with Nikon 45mm Macro lens [5].

Test Sample and Grips

- Test sample meets ASTM standards E21 [6] for elevated temperature testing and E8 [7] for subscale specimen sizing
- Sample design changes size of grips but keeps gauge section length/width consistent with E8 standards
- Utilized St. Venant's principal to have uniform axial stress in the gauge section by extending the ¼" x ¼" section from the 1.25" E8 standard to 2"

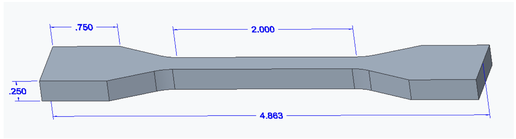

Fig. 7 Designed test sample with key dimensions.

- Utilized Abaqus software to perform finite element analysis (FEA) on test grips and samples

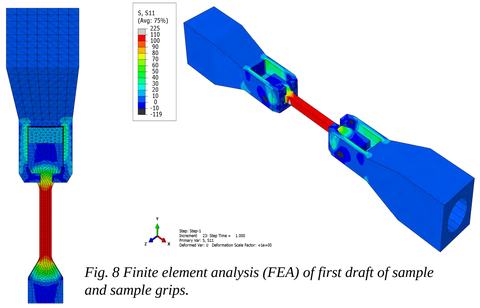

Fig. 8 Finite element analysis (FEA) of first draft of sample and sample grips.

- Using results from FEA, the grips were updated to alleviate stress concentrations
- Grips will be made from nickel super alloy to withstand high temperature environment
- Will be designed for machinability

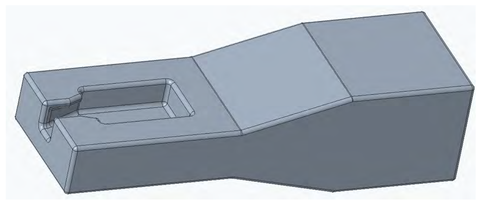

Fig. 9 Updated sample grips to reinforce weak areas and remove stress concentrators.

Conclusion

The high temperature tensile tester is currently in the design and planning phase. Designing is an iterative process. The current solution for the test sample design adheres to ASTM standards and should give reliable tensile test data. The sample grips are early in the design process and will continue to evolve. Analysis tools such as expert input and FEA of the test sample and grips will give necessary feedback for each design iteration. The digital imaging correlation system will have design constraints to overcome, and the proposed system will allow for non-contact data acquisition of specimen strain. The DIC system may need to be altered as design challenges occur.

Moving Forward

- The DIC system will be ordered and tested using the supplied software.
- Further FEA testing of the grip design
- Consultation with manufacturers about grip machinability
- Finalization and manufacturing of grips
- Mounting the tensile tester to the test frame and mounting the furnace to the tensile tester
- Test samples of materials that are of interest will be cut and tested
- Ideally, once operating, the entire testing system can be automated

Literature Cited

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